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EUCLASE FROM IVELAND, OCCURRING AS AN ALTERATION PRODUCT OF BERYL

BY

TRYGVE STRAND

With two text-figures

Abstract. Pseudomorphs of beryl from the Hovåsen feldspar quarry, Eptevann in Iveland, consist mainly of bertrandite and muscovite and contain in subordinate amounts a mineral identified as euclase by an optic and X-ray examination.

Recently a sample of beryl pseudomorphs from Iveland was sent to the Geological Survey of Norway for examination by Mr. Arthur Jacobsen of Kristiansand. The material consisted mainly of bertrandite [$Be_4Si_2O_7(OH)_2$] and muscovite, but proved to contain also the rare beryllium mineral euclase [$BeAlSiO_4(OH)$], which has not earlier been recorded from Norway.

Iveland, situated about 50 km north of Kristiansand in the southernmost part of Norway, is famous for its granite pegmatites rich in rare minerals, monographed by H. Bjørlykke (1935). The material sent by Mr. Jacobsen came from the feldspar quarry on Hovåsen, Eptevann (No. 87 in Bjørlykke's list of the pegmatite occurrences of Iveland, l. c., p. 238). As stated by Bjørlykke the large pegmatite dyke of Hovåsen contains beryl in crystals of varying size, according to Mr. Jacobsen the altered beryl with bertrandite occurs near to the margin of the dyke. It may be noted that the earlier records of bertrandite from Iveland described by Th. Vogt (1911) came from Tveit, thus not from the same locality as the material here described.

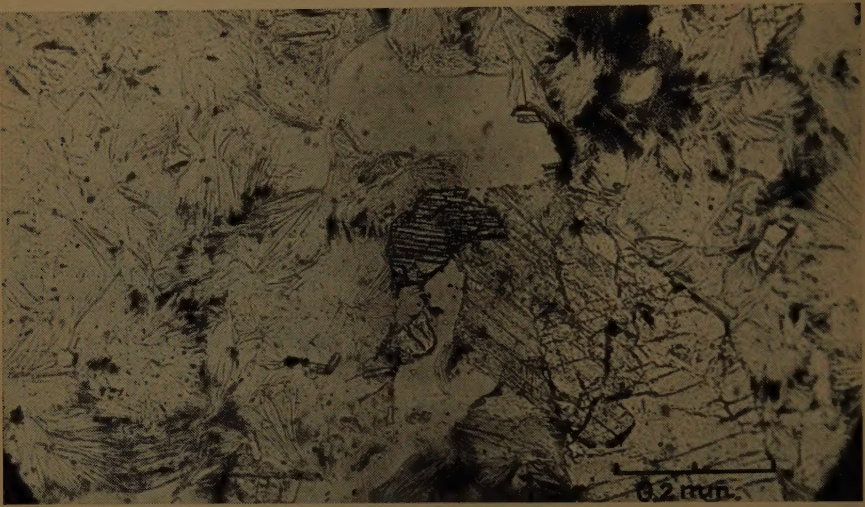

Fig. 1. Microphotograph of the beryl pseudomorph. In the center a single grain of euclase (see the text), partly covered by a loosened flake of bertrandite. The other minerals are muscovite and bertrandite (a large grain in the lower right part).

The samples at hand are made up of two pieces, one of which shows the hexagonal prism faces of the original beryl. As already mentioned, they consist of muscovite, occurring as spherulitic or sheaf-like aggregates, coloured yellowish by an iron-bearing substance, forming a matrix in which the bertrandite occurs as partly idiomorphic laths in size varying from 0.5 to 3 mm (Fig. 1). The bertrandite also occurs in vug cavities as clear laths 3 to 4 mm in size. Quartz and albite have been found in very subordinate amounts.

The bertrandite is clear and translucent. In powder preparations and in slides the rhombic symmetry is well shown by the perfect cleavages on all the three pinacoids, and almost all the grains in powder form are orientated with an optic normal, or one of the bisectrices in a normal position, γ — 1.613 ± 0.003, β — 1.603 ± 0.003, α — 1.588 ± 0.003, — 2 V 70°, measured on the universal stage. The optic constants are thus near to those given for the mineral bertrandite. As this mineral has been exactly examined and described from a similar occurrence in Iveland by Th. Vogt (1911), there should be no doubt of the identification.

When powder preparations of the beryl pseudomorphs were

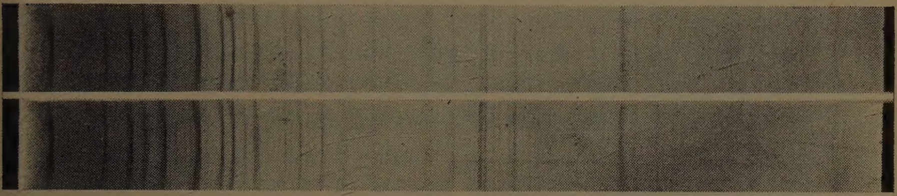

Fig. 2. X-ray powder diagrams of euclase, 9 cm camera, iron radiation with manganese filter. Upper diagram: euclase from Muso, Brazil, lower diagram: euclase separated from beryl pseudomorphs from Hovåsen, Eptevann, Iveland.

examined in an immersion liquid with an index of about 1.600, near to the mean index of bertrandite, a few grains of a mineral with index distinctly higher than the liquid were noticed in each of the samples examined. At least half of the grains in question were orientated with the optic normal in a vertical position, thus indicating the presence of a direction of good cleavage coinciding with the axial plane. Most of the grains so orientated showed cleavage cracks or a straight edge making an angle of 42° to 43° with γ. Also a second cleavage making an angle of nearly 10° with α was noticed. Refractive indices $\gamma — 1.675 \pm 0.003$, $1.655 > \beta \geqq 1.650$. Two grains properly orientated showed a positive optic axis with an angle of 40—50°, estimated from the curvature of the isogyre, with distinct dispersion $r > v$. The axial angle, 2 V, was found to be + 45° on the universal stage by the method of the characteristic extinction (Berek). The optic characters come close to those given for euclase by Larsen and Berman. There is a full agreement in cleavages and optic orientation, when the axial plane cleavage is being correlated with (010) and the two other cleavages observed with (100) and (001) of the euclase.

Of two slides prepared from the beryl pseudomorphs only one contained a single grain of the euclase (Fig. 1). It has the distinct (010) cleavage, coinciding with the axial plane, almost normal to the plane of the section and a positive optic axis near the normal of the section, 2 V ~ 40°.

Due to a proposal by Dr. Henrich Neumann the optic identification of the euclase was checked by a separation and X-ray examination of the mineral, this work was carried out at the Mineralogical-Geological Museum of the University of Oslo under the supervision of Dr. Neumann. The separation was carried out by Mr. Thor Siggerud by means of acethylene tetra bromide, sp. g. 2.97, the material being crushed to a size of 80 mesh. The only mineral to sink during the separation process was the euclase. From about 30 g of the beryl pseudomorph only some centigrammes of the euclase was obtained. The euclase thus makes up certainly less than one per cent of the material, which is in agreement with the impression gained by the microscopic examination.

An X-ray powder diagram of the separated material was taken by Mr. Jens Hysingjord, for comparison a diagram was taken of a specimen of euclase from Muso, Brazil in the collection of the Museum. The result, shown by Fig. 2, leaves no doubt of the identity.

The occurrence of the euclase together with bertrandite and muscovite makes it clear that in the present case this mineral was formed by an alteration of beryl, which in the main may have taken place according to the equation:

$$\begin{array}{cccc} 12\ \text{beryl} & +\ 4\ K_{2}0 & +\ 17\ H_{2}0 & \rightarrow \\ 100 & 5.7 & 4.8 & \end{array}$$

$$\begin{array}{ccc} 9\ \text{bertrandite} & +\ 8\ \text{muscovite} & +\ 30\ \text{Si}0_{2} \\ 33.0 & 49.5 & 28 \end{array}$$

The numbers give the percentage proportions by weight in relation to the original beryl, the proportions by volume are only slightly different. The very small contents of quartz indicate that most of the silica was removed during the process, and the presence of vug cavities shows that some net decrease in volume has taken place (cf. p. 2, *ante*). As the contents of the bertrandite can be estimated to be about one third of the pseudomorphic aggregate, there should have been no loss of Be. The formation of the euclase may be ascribed to the circumstance that potash was not available in wholly sufficient amounts to transfer all of the alumina of the original beryl into muscovite.

According to Doelter (1917, p. 600 f.) euclase has been found, besides in alluvial occurrences, as a primary mineral in mineral veins and pegmatites and in vugs in granite. As far as the writer has been able to find out, a paragenesis like the present one has not earlier been recorded for the mineral.

The material here described has been deposited in the Geological-Mineralogical Museum of the University of Oslo.

As will appear from the foregoing, the writer is greatly indebted to Dr. Neumann and to Messrs. Hysingjord and Siggerud.

Geological Survey of Norway, March 1952.

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NOEN IAKTTAGELSER OVER ISBREENES TILBAKEGANG I HORNSUND, V. SPITSBERGEN

AV

A. HEINTZ

Sommeren 1949 sendte Norsk Polarinstitutt et geologisk parti til Hornsund. Partiet bestod av en geolog, nåværende direktør Sven Føyn, to assistenter, stud. Jan Wiborg-Thune og Gunnar Mæland, og undertegnede, som fungerte som paleontolog. Partiets hovedoppgave var å undersøke de geologiske forhold i Hornsund og foreta fossilinnsamlinger. Av særlig stor interesse for meg var undersøkelsene av de devonske avleiringer. Spredte fossilfunn fra tidligere ekspedisjoner tillot ikke en sikker bestemmelse av deres alder, og derfor var en mer systematisk leting etter fossilene av betydning. Da både Føyn og jeg tidligere hadde besøkt de fleste devon-områder på Spitsbergen, hadde vi stor interesse av å foreta nøyaktigere studier også i Hornsund.

Ved undersøkelsen av devonfeltene kom vi snart til det resultat at avleiringer ved Hornsund er av mindre paleontologisk betydning. Her var bare utviklet en meget liten del av devonserien kjent fra nordkysten av Spitsbergen, og dessuten, på grunn av sterke tektoniske forstyrrelser, er fossilene mindre godt bevart. Vi kunne konstatere at de røde deler av devon-serien i Hornsund representerer de øverste lag i Wood Bay Serien (Stjørdal-avdelingen), og de sorte og grå den nederste delen av Grey Hoek Serien.

Mens Føyn med Mæland i ca. 14 dager foretok geologiske undersøkelser på sydsiden av Hornsund, arbeidet jeg og Wiborg-Thune på nordsiden. De geologiske forhold her var ikke særlig kompliserte,

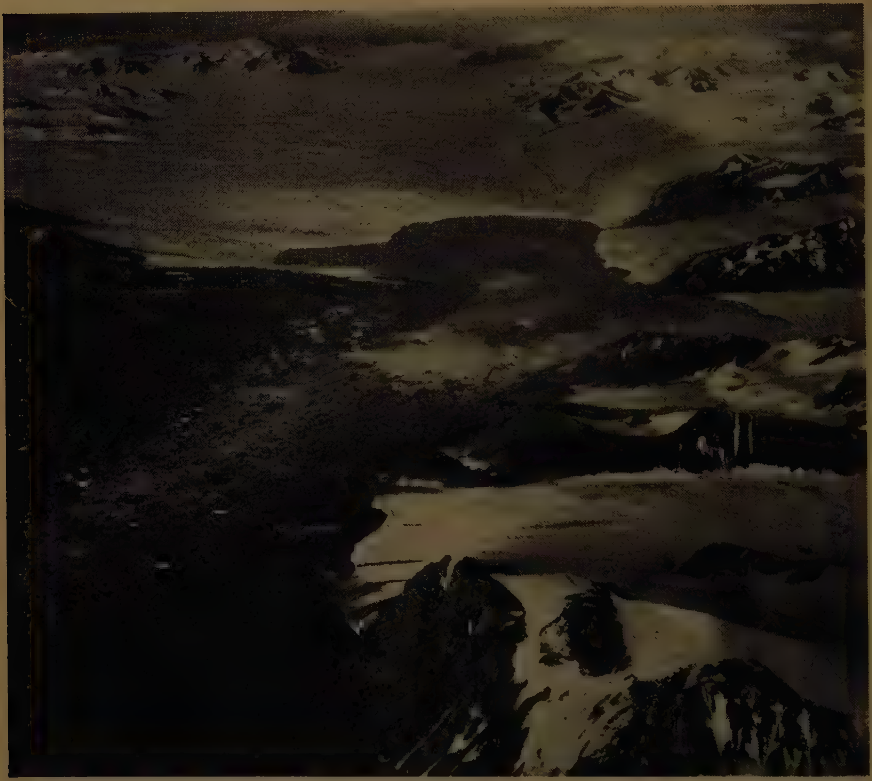

Fig. 1. Luftfoto av Hornsund, tatt rett mot Ø. (Lunche fot. 1936.)

og da lagene i det store og hele var temmelig fossilfattige, fikk jeg en del tid til overs til å undersøke isbreene og sporene etter deres avsmelting. Det er om disse iakttagelser jeg vil fortelle her.

Allerede før vår avreise til Spitsbergen, hadde cand.real. Liestøl gjort meg oppmerksom på de interessante glasiologiske forhold i Hornsund. I virkeligheten er Hornsund-distriktet, på tross av at det ligger nær sydspissen av V. Spitsbergen, et av de sterkest nedisede områder på øya. I den indre delen av fjorden munner det ut ikke mindre enn 9 større og mindre breer (Hansabre, Paierbre, Mühlenbachbre (Burgerbre), Hornbre, Bautabre, Chomjakovbre, Samarinbre, Petersbre og Körbre). Av disse er Hornbreen den viktigste. Den består i virkeligheten av en rekke sidebreer som smelter sammen og danner en imponerende ismasse, som fyller hele bunnen av fjorden

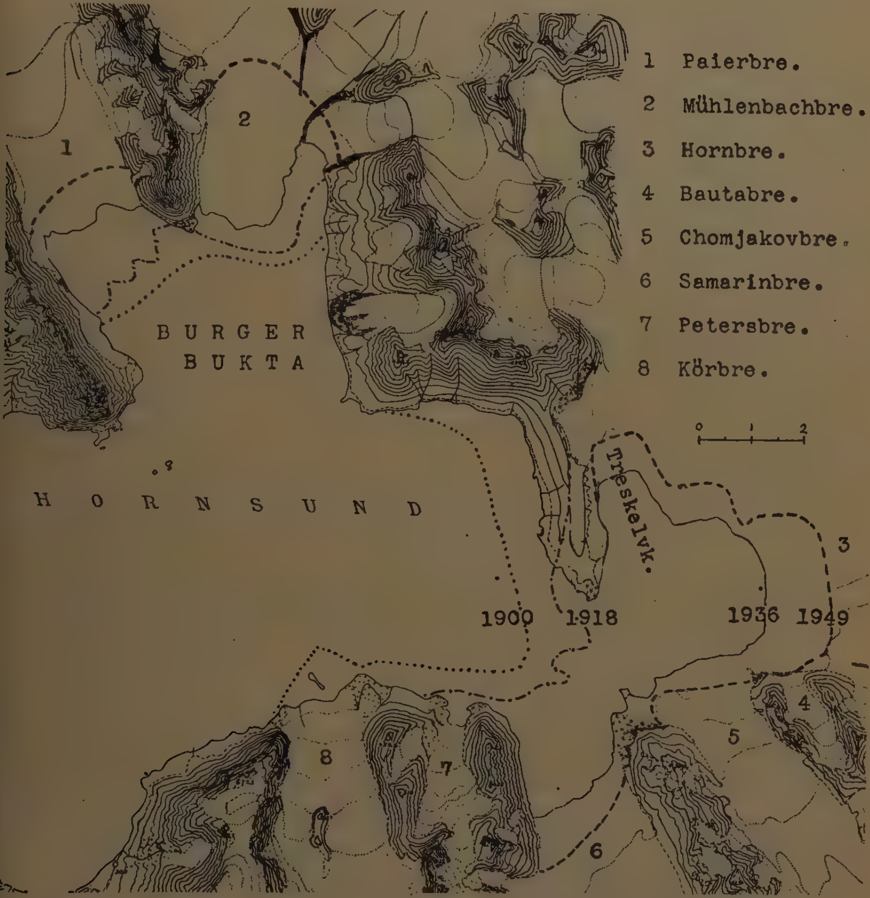

Fig. 2. Kart over indre del av Hornsund, med konturer av brefronter fra 1900 (......), 1918 (-·-·-), 1936 (———) og 1949 (- - - -).

(fig. 1). Av interesse for breundersøkelsene her er at Hornsund har vært besøkt av en rekke ekspedisjoner, som har tegnet mer eller mindre gode karter, slik at man kan danne seg et visst begrep om breenes utbredelse i tidligere tider.

Den første kartskisse stammer fra 1872, da en østerriksk ekspedisjon, under ledelse av Graf Wiltschek, besøkte Hornsund. Skissen er imidlertid så pass unøyaktig, at det er vanskelig å foreta noen sikre sammenlikninger med senere karter. Det neste kart stammer fra den russiske gradmålings-ekspedisjonen, som tilbrakte vinteren

1899—1900 i Hornsund. Dette kart gir et bra billede av sørsiden av Hornsund, men nordsiden er mindre nøyaktig tegnet. Prof. Backlund, som deltok i den russiske ekspedisjon, har opplyst meg om at nordsiden av Hornsund til stadighet var blokert av drivisen, hvilket har gjort kartering vanskelig. De neste ekspedisjoner var norske. Dosent Hoel har besøkt stedet i 1917—1918, og det ble foretatt nøyaktige oppmålinger, som har gitt grunnlag for norsk sjøkart fra 1938. I 1936 utførte dr. Orvin geologiske undersøkelser i Hornsund og samme år ble området luftfotografert. Luftfotografiene har tjent som grunnlag for topografiske kart over Svalbard Blad C 13 og E 12, hvor en ser sør- og nordkysten av Hornsund. I 1937 og 1938 arbeidet to tyske ekspedisjoner i Hornsund. Deres hovedoppgave var bre-undersøkelser. I deres publikasjon (1939) ble det reprodusert en rekke verdifulle kart.

På fig. 2 er gjengitt kart over den indre del av Hornsund — et utsnitt av kartblad C 13 og E 12 over Svalbard. Brefronter er tegnet etter: 1) et håndtegnet kart lånt fra Norsk Polarinstitutt og utarbeidet av cand.real. Liestøl, 2) kart utarbeidet av den Russiske Gradmålingsekspedisjon, 3) kart utarbeidet av tyske ekspedisjoner 1937—38, 4) luftfotoer 1936, 5) egne iakttagelser sommeren 1949. Hva våre egne iakttagelser angår, så har vi ikke foretatt noen nøyaktige målinger, men forsøkte bare å avmerke de nye brefronter på luftfotoene eller på de foreliggende kart, ved peiling på de mest karakteristiske fjellformasjoner. Det er således innlysende at de brefronter som er tegnet etter våre iakttagelser ikke kan betraktes som fullt ut nøyaktige.

Kartet på fig. 2 viser at de 6 breer som nå munner ut hver for seg i den indre del av Hornsund fra S og Ø, i 1900 dannet en stor felles bre, som dekket hele den nåværende bunnen av Hornsund. Av kartet kan man se at tilbakegangen av brefronten på disse 50 år har vært ca. 6 kilometer. Og det areal som i løpet av samme tid er blitt isfritt i det indre av Hornsund, er omkring 30 kvadratkilometer. Regner man gjennomsnitts-tykkelsen av det bortsmeltede isdekke for ca. 100 m (det var sikkert betydelig større på mange steder), kommer man til det resultat at det er smeltet bort ca. 3 kubikk-*kilometer* is! Det vil si gjennomsnittlig ca. 60 millioner m^3 is pr. år. Til dette enorme tall må man legge til all den is som smeltet bort fordi breene, i all fall i sitt nederste løp, er blitt betydelig tynnere. Sammenlikner man det russiske kart med det siste kartet (E 12) kan man bl. a. konstatere at Samarinbreen langs med Påskefjellene var ca. 200 m mektigere i 1899.

Også breene i Burgerbukta er gått betydelig tilbake. Dessverre er de russiske kart fra 1899—1900 temmelig unøyaktige i dette området. Kystkonturen av Sofiakammen er forbløffende korrekt, mens avstanden mellom S og N kysten av Hornsund avviker på ca. 1,5 km. Likeledes er bredden av Burgerbukta, konturen av dens Ø-kyst, størrelsen av breene og plasering og størrelse av fjellkammen mellom dem helt misvisende. Det samme gjelder konfigurasjonen av Hyrnefjell og Mariatoppen, men særlig fjellene bakenfor Hyrnefjellet. Men man kan allikevel se av de russiske kart at Paierbre og Mühlenbachbre i 1900 dannet en felles front, som gikk på tvers av Burgerbukta. Hoel's målinger fra 1917 er sikrere, men heller ikke her stemmer kystkonturene med de nye kartene. Dette gjør det vanskelig å trekke helt sikre brefronter. Men man kan se at brefronten nå er delt i to ved den midtre fjellrygg, selv om det bare er den ytterste spissen av den som stikker ut. Man kan også konstatere at videre tilbakegang var temmelig betydelig. For Paierbreens vedkommende sterkest i årene 1918—1936, for Mühlenbachbreen i årene 1936—1949.

Jeg nevnte før at første kartskisse over Hornsund stammer fra 1872. Selv om den er så unøyaktig at det er vanskelig å trekke opp noen sikre bregrenser, kan man allikevel se at breene stort sett ikke var nevneverdig større i 1872 enn i 1900. Det ser således ut til at den sterkeste tilbakegang har funnet sted i de siste 50 år.

I og for seg er breenes tilbakegang på Spitsbergen et velkjent fenomen, som alt tidligere har vært konstatert for mange andre områders vedkommende. Det som er av en viss interesse i Hornsund er at man har kunnet studere breenes gradvise tilbaketrekning over en forholdsvis smal fjellodde, som fra å ha vært helt dekket av is i 1900, er blitt helt isfri i 1949. Denne odden, Treskelodden, løper fra N-kysten av Hornsund rett mot S (fig. 1, 2). Den er ca. 4 km lang og ca. 1 1/3 km på det bredeste, ca. 140 m høy i den nordligste delen og blir gradvis lavere i sørlig retning. De høyeste fjellknatter på S-spissen er knapt 18—20 m. Odden er bygget opp av kalkstein-, sandstein- og skiferlag av karbonsk, permisk, men først og fremst triasisk alder. De står mer eller mindre steilt, med fall mot Ø, og kan følges videre på sørsiden av Hyrnefjellet. De hårde sandstein- og kalklag danner utpregede rygger, skiferavdelingene er

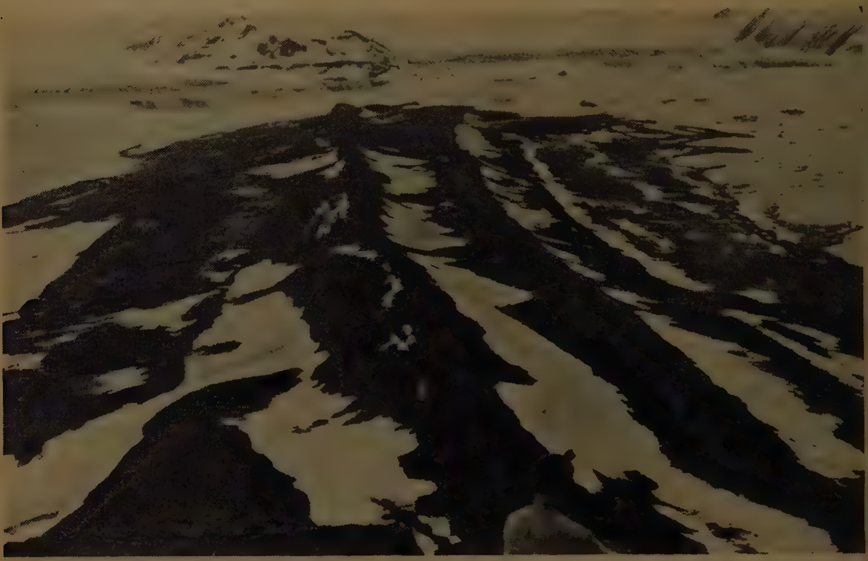

Fig. 3. Treskelodden sett rett mot S fra skråningen av Hyrnefjell. I bakgrunnen Påskefjellene på S-siden av Hornsund. (A. Heintz foto).

sterkere utvitret og danner forsenkninger (fig. 3). Treskeloddens »ryggrad« består av et mektig kalksandsteinslag. Det danner oddens høydedrag og kan følges fra Hyrnefjellet og helt til den sydligste pynten av odden. Vi har kalt det for lag 41—43. I den nordlige del av odden er denne ryggen klart synlig, i den sørlige er den i det store og hele dekket av morenemasser. Fra denne høyderyggen og vestover (mot stranden av Hornsund) finner man en rad mer eller mindre tydelige parallelt-løpende rygger. De deler hele odden i en rekke terrasse-liknende avsatser (fig. 3). Nærmere oddens V-kyst legger lagene seg mer flatt, skjærer ut i havet og danner en rekke mindre nes som stikker ut. Dette står i forbindelse med at Treskeloddens lengde-akse løper parallelt med foldningsaksen av en utpreget sadel (som en tydelig kan se på S-skråningen av Hyrnefjellet, fig. 16). Foldningsaksen løper praktisk talt rett N-S, med fall mot S, men ligger litt utenfor Treskeloddens V-kyst.

Mens oddens V-skråning er terrasseformet oppbygget, er dens Ø-skråning mer jevn. Den er så å si helt dekket av morener. Fjellet stikker bare opp noen få steder, bl. a. langs med selve Ø-kysten, særlig lengst mot S.

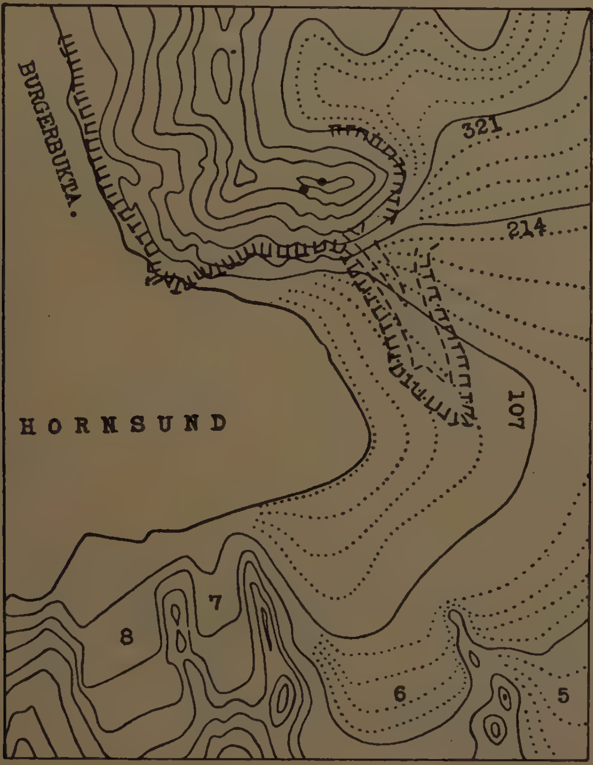

Fig. 4. Utsnitt av det russiske kart av Hornsund. (Ekvidistanse i sasjen: 50 sas. = 107 m.). Treskelodden plasert slik at den ligger »under isen«. V-kysten av Burgerbukta på det russiske kart faller da sammen med den på de nye norske kart (⊔⊔⊔) Det samme gjelder toppen av Hyrnefjell (.) og fjellets Ø-skråning. Brenavner se kart 2.

Ser man på kartet fig. 2, eller på luftfoto fig. 1, kan man med en gang se at Treskelodden står på tvers av Hornbreens bevegelsesretning. Isen har altså presset sterkt mot oddens Ø-kyst, og da den først hadde klart å komme over oddens høyderygg, var den antagelig så »utmattet«, at den hverken førte med seg nevneverdige mengder av morenematerialer eller utførte noe sterkere erosjonsarbeide. Som vi kan se av det østerrikske kart fra 1872 og det russiske kart fra 1900, var hele Treskelodden på den tiden dekket av Hornbreen og helt usynlig (fig. 4). Det er imidlertid ikke lett å bestemme hvor langt isen strakte seg mot vest. Det russiske kart er, hva N-kysten av Hornsund angår, temmelig unøyaktig, mens fjellryggene på S kysten er plasert forholdsvis riktig. Etter de siste kart (E 12, C 13) faller Treskeloddens lengdeakse sammen med en linje trukket fra toppen av Hyrnefjell til N-spissen av Påskefjellene. Trekker man en tilsvarende rett linje på det russiske kart, kommer Treskelodden til å ligge like bakenfor fronten av Hornbreen. Dette er meget usannsynlig. For det første skulle man da vente at den relativt bratte V-kysten av Treskelodden, i all fall delvis, ble liggende isfri. For det annet kan man fra kotene på Hornbreen, tegnet på det russiske kart, ikke merke noe til tilstedeværelsen av Treskelodden umiddelbart bakenfor brefronten. Etter kotene å dømme steg breen ganske jevnt oppover. Selve brefronten var meget lav ved N-kysten, men stiger til ca. 20 m (under 10 sasjen) på midten. Da Treskeloddens høyde-platå ligger over 50 m høyt, og vi i dens nordligste del har en kam som er over 100 m, med høyeste punkt lengst mot N på hele 140 m, må man vente at istykkelsen må være minst mellom 100 og 150 m på det stedet odden lå. Plaserer man Treskelodden på denne måte i forhold til kotene på det russiske kart, viser det seg at konturen av V-kysten av Burgerbukta (etter de siste kartene) faller helt sammen med det russiske kart. Det samme gjelder forholdet mellom Treskelodden og 1) toppen av Hyrnefjellet og 2) Ø-skråningen av Hyrnefjellet (se fig. 4). Selv om det russiske kart er temmelig unøyaktig her, får man ved en slik plasering av Treskelodden så gode overensstemmelser med de mest iøynefallende trekk i landskapet (kystlinje, fjelltopp, fjellside) og Hyrnebreens tykkelse (som akkurat på dette sted er basert på 2 nøyaktige observasjoner), at det er rimelig å anta at Treskelodden virkelig lå omtrent 1 kilometer bak brefronten.

På selve Treskelodden kan man tydelig skille mellom to områder (fig. 5). Det ene, som omfatter den nordlige halvparten av oddens vestskråning, og således slutter seg direkte til Hyrnefjellet, er praktisk talt fri for morenemateriale. Vegetasjonsdekket er her relativt tett*, og fjellknausene som stikker opp er forholdsvis sterkt forvitret og opprevet. Mange steder finnes store steinrøyser av kantede, uregelmessige blokker.

Det andre området omfatter hele den østlige skråning av odden og dessuten hele dens sydlige halvpart. Her er morenematerialet helt dominerende, fjellpartiene stikker bare frem noen få steder og er da som regel avrundede og isskurte. Man finner ingen større steinrøyser. Vegetasjonen er meget fattig, på enkelte steder mangler den nesten helt. Til gjengjeld finner man her på de fleste steder rikelig med marine musling-skall.

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* Merkelig nok fant jeg ingen steder på Hornsund-området *Dryas octopetala* — ellers så alminnelig på Spitsbergen.

Går man langs med oddens høydedrag (altså langs med laget 41—43) fra N mot S kan man best følge Treskeloddens gradvise avsmeltnings-historie.

Innerst ved Hyrnefjellet er Treskelodden ca. 140—145 m høy. Dette partiet har antagelig ikke vært dekket av isen på lenge. Mellom ofte grove steiner danner vegetasjonen her en mer eller mindre sammenhengende matte, og skuringsstripene er ikke å se. Går man litt lengere ned mot S avtar høyden gradvis. Her treffer man snart spor etter isskuring på fjellet. Stripene går i det store og hele i Ø—V retning; men de finnes ikke overalt, og er heller ikke særlig tydelige, da selve fjellet er en del forvitret. De finnes hovedsakelig på hårde fjellknauser, som skråner mot Ø. Det er opplagt at her har isen gått over odden for ganske mange år siden. På det samme tyder også vegetasjonen, som er forholdsvis rik. Steinene er for det meste bevokset med lav. Lag 41—43 har her et temmelig steilt fall mot Ø.

Ca. 500—600 m mot S fra det høyeste punkt av odden finner man et tydelig innhakk i fjellryggen (fig. 5, I). Det ligger på ca. 115 m. o. h. Det er ikke vanskelig å se at det er et gammelt bekkeleie. Engang i tiden rant her isbre-bekken ned mot Hornsund. Man kan tydelig følge bekkeløpet ned gjennom alle »terrassene« på Treskelodden og helt ned til havet. Smelte-vannet fra mange av de store snefonnene som ligger mellom ryggene på Treskelodden rinner fremdeles i disse gamle bekkeleier. Men den øverste bekkeskjæringen på kammen av Treskelodden er helt tørr og sikkert temmelig gammel. Man finner her en sparsom vegetasjon mellom steinene og en del lav på steinene; det er mange år siden vannet rant her.

Fortsetter man videre S-over langs med høydedraget, merker man en tydelig forskjell. For det første er vegetasjonen påfallende fattigere. Man ser lite av mose og lav, og blomsterplantene står spredt i små klynger. Det er først og fremst polarvalmuen (*Papaver radicatum*) man treffer på. Fjellet, som stikker frem overalt, er tydelig isskuret; også her går isstripene i Ø-V retning. Parallelt med fjellkammen, men litt lengere mot Ø, løper en temmelig høy,

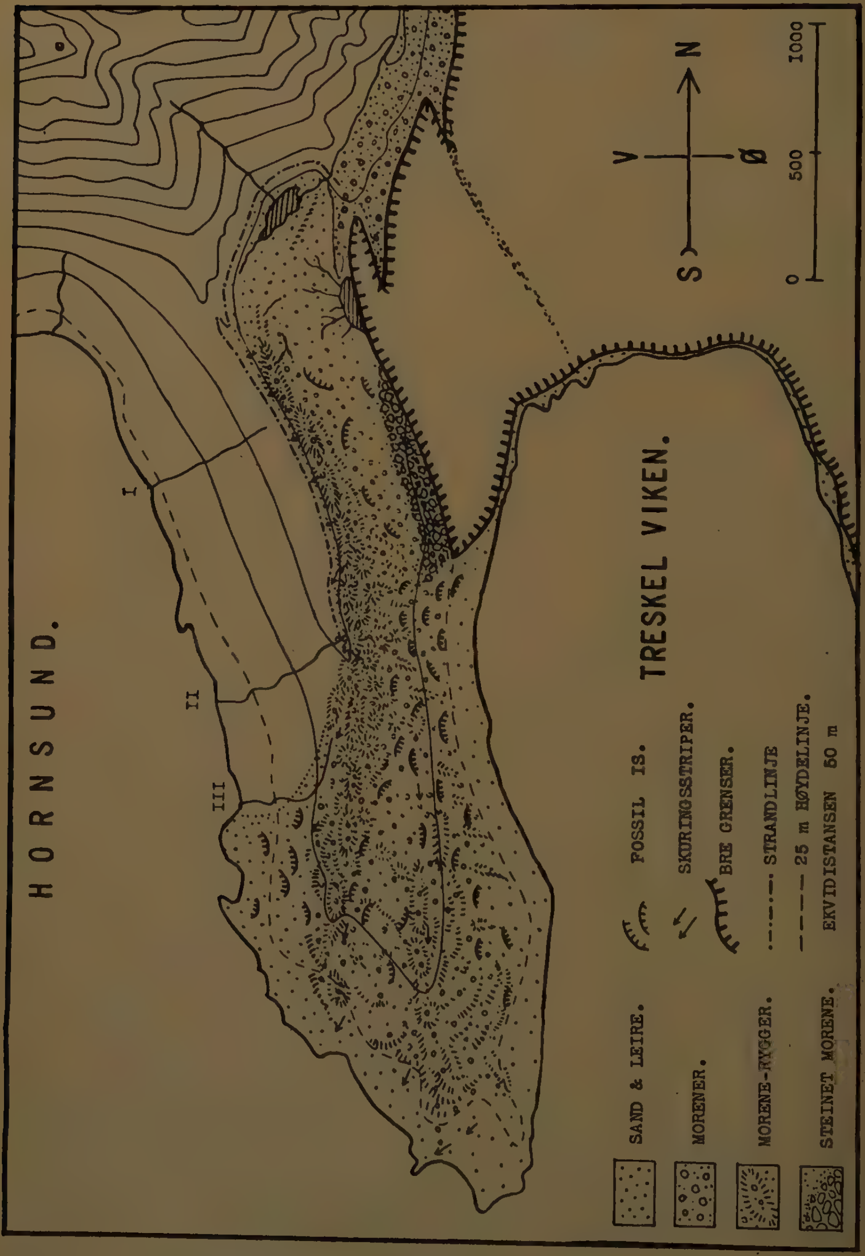

Fig. 5. Kart over Treskelodden, basert på de nye norske kart, og supplert ved egne iakttagelser.

bred og bratt morenerygg. Det blir således dannet en forholdsvis smal og dyp spylerenne langs med fjellsiden. Den bratte fjell-veggen (lagflaten av lag 43) som begrenser denne rennen fra V, er renvasket og fri for lav eller annen vegetasjon. Det er opplagt at det må ha rent en bekk her for ikke så lenge siden. Omtrent 800—900 m fra det første bekkeleie støter man på en ny dyp kløft i fjellveggen; ganske betydelige vannmasser må ha rent her forholdsvis nylig (fig. 5, II). Man finner et dypt innhakk i lagene 41—43, og litt lavere ned blir det til den rene canyon. Fjellet i kløften er blank-slitt, og steinene avrundede. Man kan tydelig følge et bekkeleie helt ned til havet gjennom alle de 6 terrasser på oddens vestkyst. På enkelte steder dannes det dype kløfter, på andre finner man store opphopninger av løst materiale. Smeltevannet fra snefonnene renner fremdeles i bekken. Høyden av bekkeleiets øverste kant er ca. 110 m. Umiddelbart S for denne bekkekløften svinger den før omtalte morenerygg, som løper parallelt med Treskeloddens høydedrag, mer SV og går over høydedraget (lag 41—43). Herfra og helt til sydspissen av Treskelodden er fjellgrunnen praktisk talt helt dekket med moremasser. Akkurat der hvor moreneryggen går over høydedraget, finner man store opphopninger av grusmaterialer, som delvis danner meget høye, merkelig nok delvis lagdelte hauger. Etter plaseringen av bekkeskaret og anordningen av grusrygger og hauger er det klart at bekken som rant gjennom skaret først løp et langt stykke i spylerennen mellom breen og Treskeloddens høyderygg, men der hvor denne rennen ble fylt opp av de store grusmassene, skar den seg over ryggen og ned til sjøen.

Men hvor kom så vannet i denne bekken fra? Det var delvis smeltevann fra selve breene, men ved en nøyere undersøkelse kunne man konstatere at bekkefaret også ga avløp for en ikke ubetydelig *isdemmet sjø*. På den nordøstlige skråningen av Treskelodden, der hvor den gradvis går over i den sørøstlige skråningen av Hyrnefjellet, ser man nemlig meget tydelig en *strandlinje*. Den er skåret inn i grus-skråningene, men kan også tydelig sees der hvor det faste fjellet stikker frem, da det ikke vokser lav på de fjellpartier og steiner som ligger under strandlinjen, mens de ovenforliggende er sterkt lavbevokset. Da lavene for det meste er svarte, er grensen forholdsvis skarp og lett synlig selv på avstand (fig. 6, 7).

Strandlinjen ligger på ca. 110—112 m høyde. Selve sjøen var således i N og V begrenset av Hyrnefjellet og Treskelodden, mens

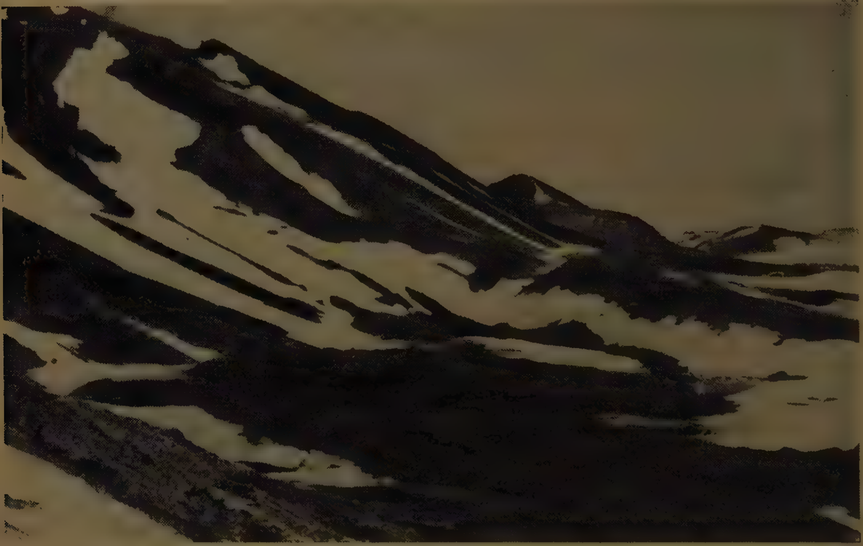

Fig. 6. Utsyn fra Treskeloddens høydedrag mot NNØ. I forgrunnen kalklag 41—43. I bakgrunnen Ø-skråningen av Hyrnefjellet. Man ser bunnen av isdemt sjø, og strandlinjen på fjellskråningen. (A. Heintz foto).

den fra Ø og S var demmet opp av Hornbreen. Sjøen var sikkert ikke nevneverdig bred, men til gjengjeld lang og dyp (fig. 17, A). For øyeblikket finner man mot Ø en forholdsvis lav morenerygg, mot S derimot resten av den opprinnelige isbre, som nå er helt ubevegelig og har en ubetydelig mektighet. Bunnen av sjøen er nesten horisontal, bare dekket med mindre fordypninger og små grushauger, den ligger ca. 30—40 meter under strandlinjen (altså ca 70—80 m.o.h.) (fig. 7). Et par små vann er fremdeles demmet opp av isbreen, deres avløp går tydeligvis under isen. Da den øvre delen av spylerennen langs med øst-siden av Treskelodden ligger betydelig høyere enn bunnen av sjøen og skråner gradvis ned mot den, siler nå smeltevannet gjennom rennen ned til sjøbunnen, og gjennom mindre vannpytter og småbekker faller det tilslutt ut i den siste rest av den isdemte sjøen (fig. 8).

Den gang den isdemte sjøen var stor, fikk den imidlertid det vesentligste vann-tilsig fra en helt annen kant. I det nordøstre hjørne av sjøbassenget ser man fremdeles tydelig et bekkefar, som førte vannet N-V fra. Denne bekken løp mellom isbreene og den NV-

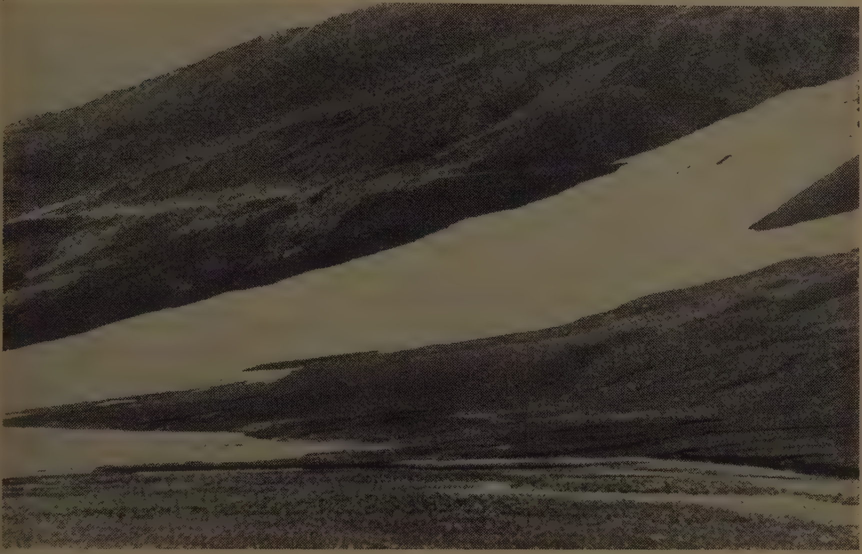

Fig. 7. Utsyn fra bunnen av isdemt sjø mot NV. På den bratte skråning av Hyrnefjell ser man tydelig strandlinjen. (A. Heintz foto).

gående skråningen av Hyrnefjellet og samlet smeltevannet fra de store og bratte breene som ligger bakenfor Hyrnefjellet. Like overfor sjøen dannet bekken en veritabel foss, da den her gikk over en fjellknaus (fig. 6). Man kan fremdeles helt tydelig se de blankpolerte steinene og dype renner i fjellet. For øyeblikket er bekken ganske liten. Største delen av smeltevannet går nå dypere ned, delvis langsmed, delvis under den nåværende isbre. På den tiden da den isdemte sjøen eksisterte, lå altså breens overflate ved Treskelodden minst 140—150 m.o.h. (sannsynligvis betydelig mere), mot ca. 70—80 m nå.

Fortsetter man nå å gå videre langs med Treskeloddens høydedrag mot S, ligger, som før nevnt, de høyeste kalksteinslag 41—43, som dannet oddens høydedrag lengere mot N, helt *under* moremassene. Man befinner seg nå i et typisk morenelandskap, med uregelmessige morenerygger, grushauger, dype renner, store steinblokker m. m. (fig. 9). Omtrent 400—500 meter fra bekken nr. II, kommer man til et nytt bekkeleie (fig. 5, III). Det skjærer seg ikke gjennom lagene 41—43, de er her helt skjult av morener, men det er

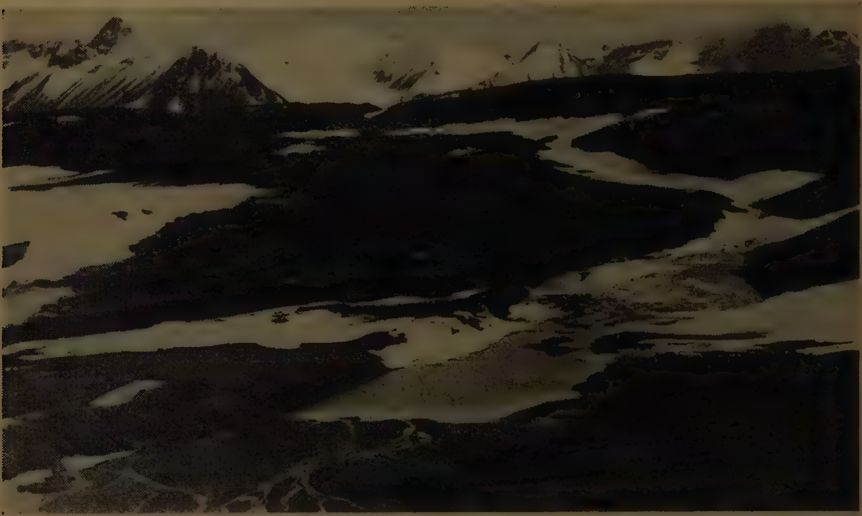

Fig. 8. Utsyn fra strandlinjen mot S. I bakgrunnen Traum-kammen. I forgrunnen Ø-skråningen av Treskelodden. Til høyre høydedraget, midt på bildet skaret for bekk II. Sneen markerer spylrenne langs med kammen. Nederst bunnen av isdemt sjø, lengst til venstre rester av breen. (A. Heintz foto.)

først synlig ved lagene 37 og kan følges helt ned til sjøen. Bekkefaret er dypt og friskt. Det er fremdeles ikke så lite vann som renner der. Det stammer fra snefonner som ligger mellom moreneryggene og fjellskråningene. Denne bekken dannet avløp for smeltevannet fra breen etter at bekk II var helt eller delvis tørrlagt. Isen dekket da fremdeles hele sydspissen av halvøya og nådde antagelig havet 1,5—2 km fra sydspissen (fig. 17, B). I følge de karter og fotografier som foreligger fra Hoel's besøk til Hornsund i 1918, var det omtrent på den tiden, eller noen år tidligere, at denne bekken var i full virksomhet. De grusmasser som dekker hele sydspissen av Treskelodden helt fra bekkeleie II og til spissen er, som nevnt før, helt »ferske«. Her er nesten ingen vegetasjon, bare noen polarvalmuer her og der, noen få gressarter og en del andre høyere planter, men det er lite av både mose og lav.

Forsøker man nå å rekonstruere den videre avsmeltning av breen, ser man at den litt etter litt har forandret sin bevegelsesretning. I områdene ved bekk I og II fant man at skuringsstriper gikk mer eller mindre rett mot V. Det tyder på at breen veltet seg over Treskelodden. I de fåtallige fjellpartier som stikker opp av

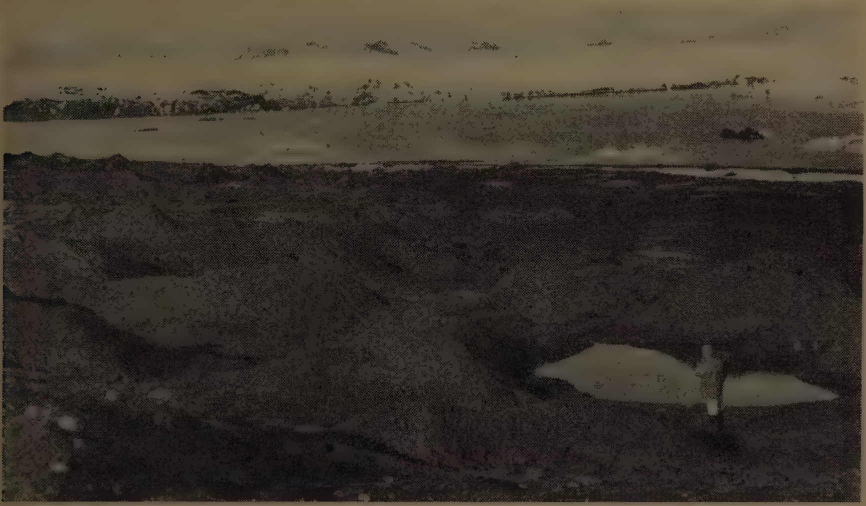

Fig. 9. Utsyn fra høyderyggen mellom bekk II og III mot ØNØ. Typisk morenelandskap. I bakgrunnen Treskelviken og kystene av en ny odde på dens Ø-side. (A. Heintz foto).

morenene mellom bekk II og III finner man skuringsstriper som går nærmest i N-S retning. Breen gikk nå mere langs med odden, ikke på tvers av den. Av plaseringen av morenerygger og fordypninger kan man slutte seg til at breen nådde havet midt på den sydvestlige stranden av odden. Selve sydspissen er relativt bratt med delvis høye fjellkammer, som muligens stakk opp av isen. Her finner man skuringsstriper som svinger fra Ø-V til NØ-SV og tilslutt nærmest rett N-S.

Breen har nå minket betydelig, slik at den isdemte sjøen er blitt mer og mer uttappet. Den fikk nå sitt avløp mot SØ, over breen, og jo sterkere breen smeltet, desto mindre ble sjøen. Man kan på flere steder, under den mest markerte strandlinjen på 110 m, finne spor etter lavere, ikke så tydelige strandlinjer. Litt etter litt hadde bekkene funnet vei under isen og inn i bukten bak Treskelodden, og sjøen ble da helt tømt.

Store deler av isen, som opprinnelig dekket de SV deler av Treskelodden, blir nå liggende død, avskåret fra nye tilførsler. Mengder av smeltevann, med grus og slam, ble imidlertid fremdeles ført fra den høytliggende breryggen langs med oddens lengde-

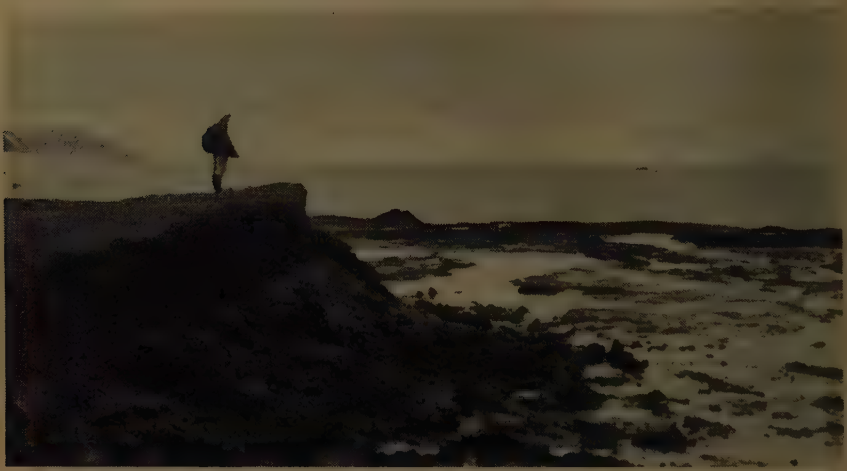

Fig. 10. V-kysten av Treskelodden, S for bekk III. Utsyn mot SV. Til venstre kanten av grusplatået, som hviler på fossil is. Man ser isen i branten. Til høyre leir-søle og vann, dannet ved tining av isen og ras av platåets kant. (A. Heintz, foto).

akse, og ned til sjøen mot V. Dette grus og slam dekket store partier av død is, som fremdeles finnes mange steder på SV-delen av odden. Svære platåer, som er dekket med tykke lag av slam og grus, ligger i virkeligheten på mektige islag. Der hvor bekkene graver seg dypere ned kommer den blå ismassen frem. I sommerens løp tiner isen litt etter litt vekk, og store leir-ras styrter ned i bekkene og forvandler store områder av odden, i nærheten av sjøen, til ufremkommelige gjørme-pøler (fig. 10).

Ved den videre avsmeltning flyttet brefronten av Hornbreen Ø for spissen av Treskelodden. Bukten bakenfor Treskelodden — Treskelviken — ble gradvis mer og mer isfri — og derved ble den direkte isstrømmen fra Hornbreen til den sydlige delen av Treskelodden brutt. Det som ble igjen av isdekket på Treskelodden er nå blitt død is. En svak tilførsel kunne nå odden bare fra NØ. Den siste bretungen som munnet ut i havet på V-siden av Treskelodden, løp på skrå mot SV mellom oddens S-spiss og de store morenerygger mer mot NV (fig. 17, C). Rester av denne istungen er muligens ikke helt avsmeltet ennå, da man i den dalen hvor den lå for ca. 20 år siden ennå finner store snefonner med en del is under.

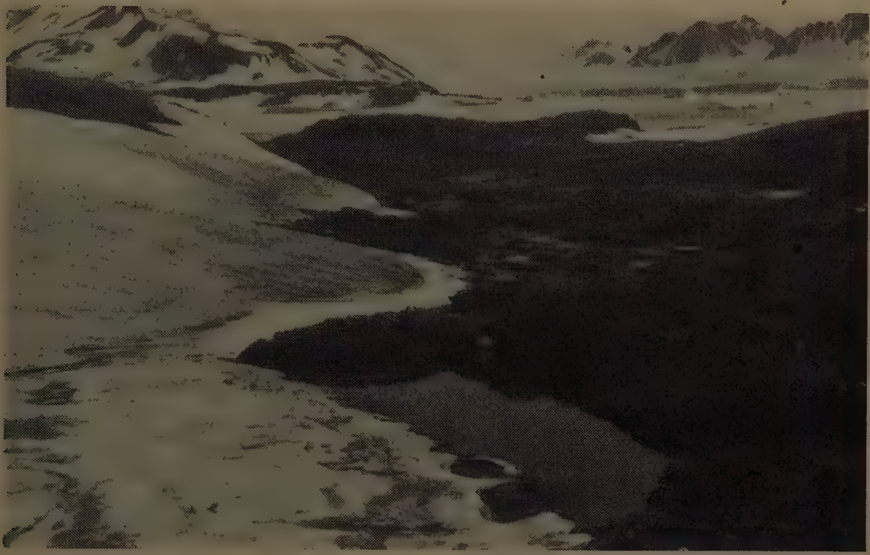

Fig. 11. S-spissen av Treskelodden. Dalen hvor den siste bretungen gikk ut i havet på V-kysten av odden. Til venstre i forgrunnen snefonn med rester av is under. Til høyre morenemasser over fossil is. I bakgrunnen Meranfjellet og Påskefjellet på S-kysten av Hornsund. (A. Heintz foto).

På sidene er det også stykker av begravet fossil is, som gir opphav til mindre ras og bløtt, ufremkommelig terreng (fig. 11).

Ø-kysten av Treskelodden viser et eiendommelig billede av land som ganske nylig er blitt fritt for isdekket (i de siste 10 år). Vegetasjonen mangler så å si helt, bare noen få spredte små planter finnes enkelte steder. På fuktige steder, på slam og ved vannpytter, er det et tynt grønnlig overtrekk av alger. Overalt ser man grus, slam, delvis sand; overalt rinner det store og småbekker fra snefonner og fossil is, som ennå finnes på indre deler av odden (fig. 9, 12). Morenematerialet danner lange rygger, pyramider, platåer, mens den fossile isen ligger som egentlig underlag. Så snart bekkene graver seg litt lengere ned får man se den blanke blå ismassen (fig. 13). Slam og sand forvandles til ufremkommelige leirpøler, og elvene fører umåtelige mengder finere og grovere sediment-materiale inn i bukten, som er helt grumset av slammet. Går man helt til bunnen av Treskelviken, kommer man til de siste rester av isbreer, som nå har trukket seg så langt tilbake at fastlandet stikker frem overalt: både i buktens bunn og til og med på den andre siden av den (fig. 9, 14). Herav

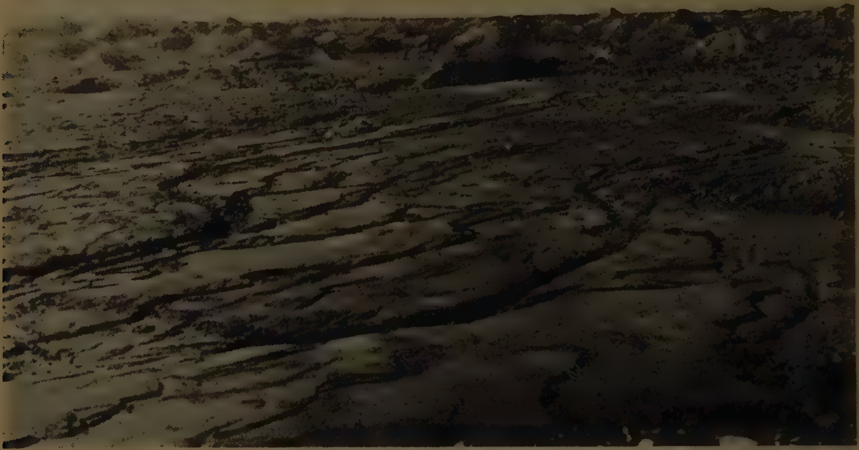

Fig. 12. Ø-kysten av Treskelodden. Smeltevanns-bekker i forgrunnen, morener over fossil is i bakgrunnen. (A. Heintz foto).

kan vi slutte at det parallelt med Treskelodden ligger en annen odde, foreløpig nesten helt dekket av is, slik som Treskelodden var det for ca. 50 år siden.

Brefronten i bunnen av Treskelviken er forholdsvis høy — 10—12 m — men sterkt oppløst og full av sprekker (fig. 14). En mengde vann renner overalt, og styrter ofte ned som veritable fosser (fig. 15). Det er smeltevannet for hele brekomplekset NØ for Treskelodden, som tidligere rant gjennom resp. I, II og III bekkene mot V-bredden av odden. Enkelte av de lavest-liggende sprekkene var helt og holdent fylt med grus, sand og leire (fig. 14). Når breen tiner blir de liggende som mer eller mindre lange, sammenhengende grusrygger, som stikker rett ut av breen. Resten av slike leir- og grusrygger så vi også mengder av lengere mot S på de steder som nylig var dekket av is. Der kunne de gå som lange leir-»slanger« i breens opprinnelige bevegelses-retning. I årenes løp blir de vasket ut av smeltevannet (fig. 16).

Man må anta at hvis smeltningen fortsetter i samme tempo som hittil, vil også bunnen av Treskelviken snart bli helt isfri, og den relativt lille bretungen som nå ligger Ø for Treskelodden vil forsvinne helt og holdent, selvfølgelig unntatt en stor mengde av fossil is,

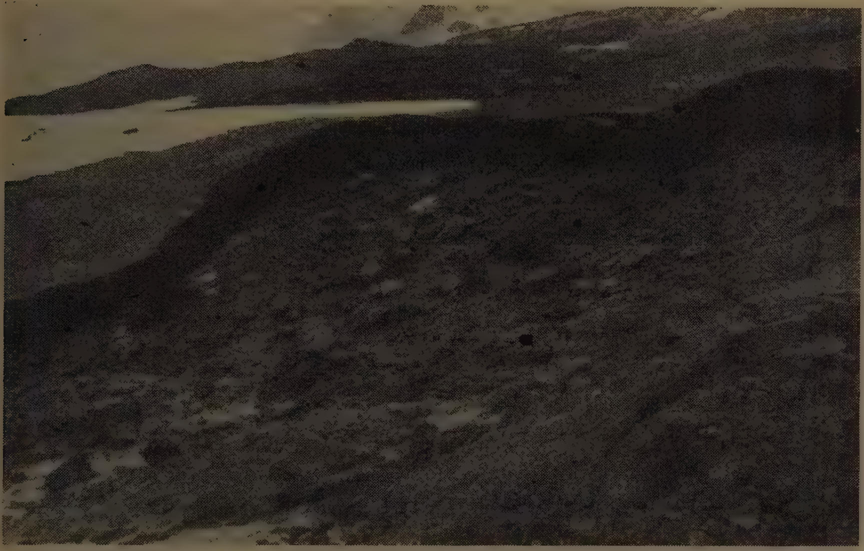

Fig. 13. Ø-kysten av Treskelodden. Fossil is under morene-masser. I bakgrunnen Horntinn. (A. Heintz foto).

som blir liggende i årevis, dypt begravet under ofte mektige lag av morener og grus.

Vil man i korte drag repetere avsmeltningsforløpet av den delen av Hornbreen som dekket Treskelodden, så må man anta, etter de kart som foreligger, at inntil ca. 1900 foregikk det ikke noen nevneverdig avsmeltning. Den gang var hele Treskelodden dekket av Hornbreen, og brefronten gikk ut i havet sannsynligvis ca. 1 km *foran* Treskelodden V for den (fig. 2). Breen gikk således tvers over Treskelviken og Treskelodden og beveget seg noenlunde i Ø-V-lig retning. Smeltevannet rant gjennom bekk I på Treskeloddens V-side.

Etter ca. 10 års forløp (1910) var den nordlige halvparten av Treskeloddens V-kyst blitt isfri (fig. 17 A), og fronten av Hornbreen begynte litt S for oddens midte. Breen gikk ikke mer i så utpreget Ø-V retning, men mer langs med oddens høydedrag NØ-SV-over. En betydelig isdemmet sjø ble nå dannet mellom breen og fastlandet. Den fikk sitt avløp gjennom bekk II.

Omkring 1920 var breens retning blitt ennå mer forandret (fig. 17, B). Fronten av Hornbreen hadde trukket seg betydelig til-

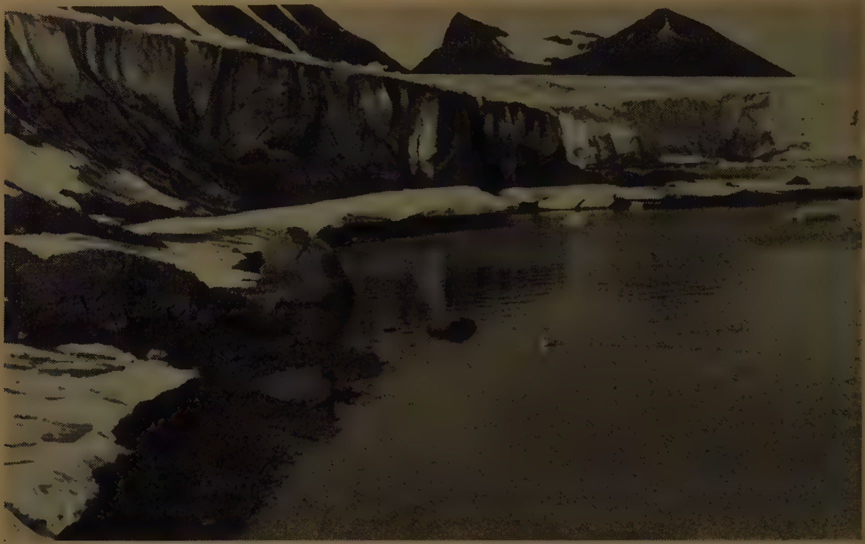

Fig. 14. Utsyn fra Ø-kysten av Treskelodden rett mot N. Bunnen av Treskelviken med brefronten av den »døde« bre. Man ser på et par steder grusrygger som stikker ut av bresprekker. (A. Heintz foto).

bake — og gikk omtrent rett S-over fra spissen av Treskelodden. Bare SV-delen av odden var dekket av breen. Breen hadde tinet så sterkt nå at den isdemte sjøen sannsynligvis ikke lenger hadde sitt hovedavløp mot SV gjennom bekk III, men vannet rant mer SØ-over. Bekk III gir imidlertid avløp for hovedmengden av brevannet.

Ca. 10 år senere — i 1930 — har fronten av Hornbreen flyttet seg Ø for Treskelodden (fig. 17, C). De første antydninger til Treskelviken er blitt synlige. Isen på selve odden er nå nesten ubevegelig og dekker hovedsakelig bare Ø-siden, unntatt en liten tunge som sannsynligvis når nesten ut til havet nær S-spissen av odden.

I 1936 var Treskelodden så å si helt isfri, unntatt en stripe av død is langs med den østlige delen (fig. 17, D). Den isdemte sjøen var nå helt tømt, avløpet for smeltevannet går mot SØ inn i den nå store og dype Treskelviken.

Til slutt, i 1949, har Hornbreens front trukket seg ennå sterkere tilbake (fig. 5). Bakenfor Treskelodden — på den andre siden av Treskelviken — er en ny odde synlig. Og bak denne igjen en ny. (Disse parallelle odder, som løper i N-S retning, står i forbindelse med hele den geologiske struktur av den indre delen av Hornsund). Den

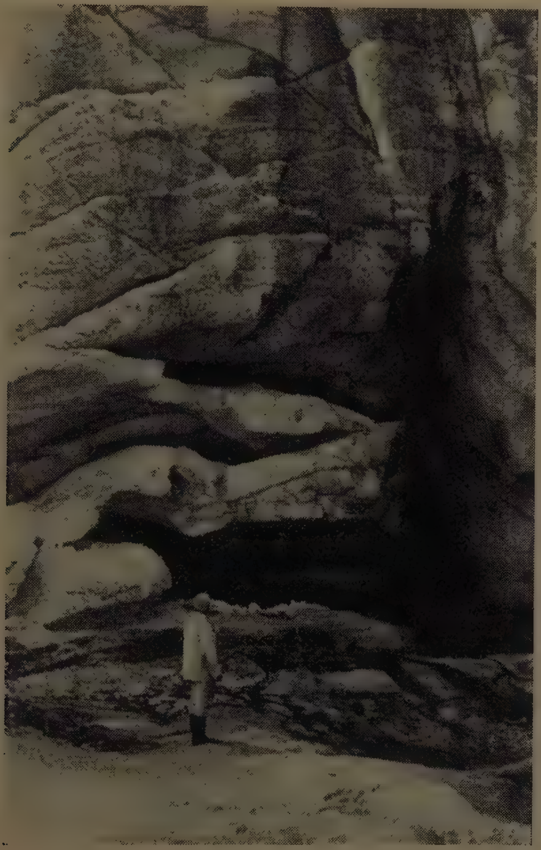

Fig. 15. Brefronten i bunnen av Treskelviken. Breen er sterkt »forvitret«. En foss av skittent vann styrter fra sprekken til høyre. (A. Heintz foto).

siste rest av breen i N-hjørnet av bukten er ubetydelig. Den er helt død, og smelter fort vekk.

Jeg har allerede nevnt at på SV-siden av Treskelodden fant vi rikelig med muslingskall i morene-gruset. Til å begynne med, når vi gikk langs med stranden og fant bruddstykker av muslinger få meter over havet, trodde vi at det her dreiet seg om utvaskede kvartære skjellbanker, som er alminnelige på Spitsbergen. Deres høyde over havet varierer sterkt. Det var imidlertid eiendommelig at skjellene bare fantes på den sydlige halvparten av odden, men aldri på den nordlige, og heller ikke lengere mot V langs med N-kysten av

Hornsund, til tross for at man her kunne se ganske tydelige strandterrasser i et par forskjellige høyder. Det dreier seg her om følgende arter: *Chlamys islandica, Mya truncata, Astarte borealis* og *A. eliptica* er meget alminnelige. *Saxicava arctica* er mer sjelden. Dessuten finnes *Litotamnium* på mange steder, derimot er *Balanus* og *Buccinum*-arter sjeldne. De fleste av disse former lever den dag i dag ved Spitsbergens kyster, og mange av dem er alminnelige i skjellbankene opp til 30 m.o.h. (etter Feyling-Hanssen).

Da vi så senere begynte å gå høyere opp på Treskelodden, viste det seg at jo høyere vi kom, desto rikere og bedre bevart var muslingskallene. På det øverste platå var det delvis overmåte store mengder av muslinger, og vi fant dem helt ned til Ø-kysten av odden, men de var ikke utbredt over hele morene-området. På den N-lige delen av halvøya fantes det ikke spor av skjell hverken i leire, grus eller sand. Man kunne trekke en ganske skarp grense som gikk noe på skrå SV-NØ-over. Sønnenfor den fant man muslinger overalt, nordenfor manglet de helt. Muslingene lå helt opp til ca. 100 meters høyde. Man kunne således umulig tenke seg at de fantes her fordi havet hadde stått så høyt i den tid de levde. Så høye havterrasser med rester av muslinger kjenner man ikke ellers på Spitsbergen. Universitetsstipendiat Feyling-Hanssen har opplyst meg om at de høyeste banker han fant lå på ca. 65—70 m.o.h. De inneholdt bare *Mya* og *Mytilus*.

Den eneste forklaring på muslingenes tilstedeværelse er at de var transportert *av isen* dit hvor de ligger nå. Det stemmer også meget bra med den skarpe begrensning av deres utbredelse.

Breen hadde på sin vei til Treskelodden passert over rike skjellbanker og dradd skjellene med seg. Når så breen smeltet bort, ble muslingene liggende igjen. Det er naturlig å anta at det er fra bunnen av Treskelviken at leire og grus med muslinger ble rotet opp og avsatt på Treskelodden. Også andre steder på Spitsbergen kjenner en slike avsetninger. Det eiendommelige ved våre funn er imidlertid at skjellene er så utmerket bevart. Selv de store skjell av *Chlamys islandica* var ofte ganske hele til tross for at de lå i grov grus; mindre skall fantes svært ofte parvis sammen (*Astarte, Mya*), slik at høyre og venstre skall berørte hverandre. Et Balan-skall, med de fleste enkelte plater liggende tett ved siden av hverandre, ble også funnet, o.s.v. Det er nesten ufattelig at så pass skjøre ting som muslingskall kunne transporteres et relativt langt stykke vei oppover av

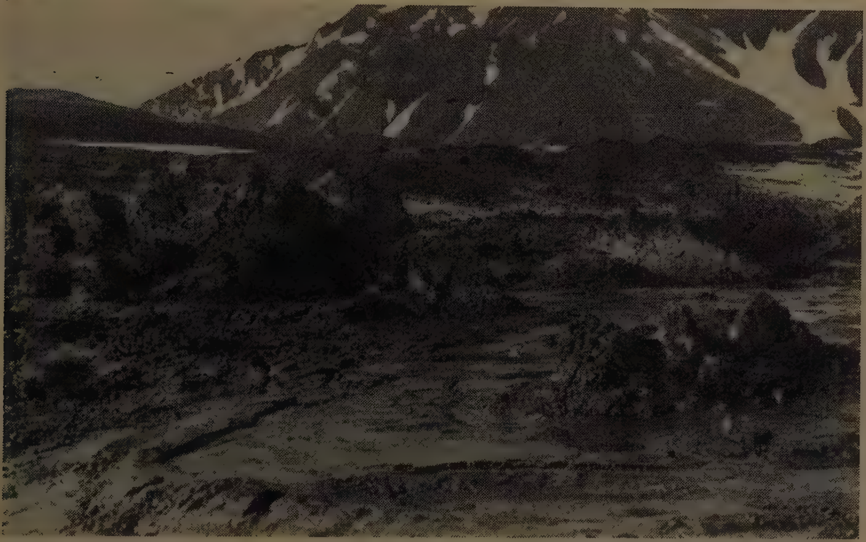

Fig. 16. Utsyn fra Ø-kysten av Treskelodden mot NNV. Leir-rygger og pyramider der hvor breen lå for ca. 10 år siden. I forgrunnen leir-bekker. I bakgrunnen Hyrnefjell. (A. Heintz foto).

isen, uten å bli knust og ødelagt, ja til og med uten at høyre og venstre skall var blitt fjernet fra hverandre. Den eneste forklaring må være at skallene var transportert i større eller mindre leirstykker eller frosne grusklumper, så de var beskyttet under transporten. Høyt på morenen (ca. 100 m) fant vi også en ganske stor trestamme (drivved) og rester av et dårlig bevart hvalskjelett. De må også ha vært transportert hit av isen østfra.

Et par andre merkelige skjellfunn gjorde Føyn på andre steder i Hornsund. Det første funn stammer fra den odden som ligger bakenfor Treskelodden på den annen side av Treskelviken, og som ennå er nesten helt dekket av is (fig. 9). Ved å krabbe opp den bratte fjellskråningen kom Føyn på høyde med breoverflaten, og oppdaget at oppå den lå det rikelig med skjell av *Mya truncata*, delvis inni leirklumper. De var også godt bevart, og mange var hele. Sannsynligvis er de gravet opp av breen fra havbunnen i bukten, som for øyeblikket er helt dekket av isen, og ligger bakenfor denne odden.

Under sine undersøkelser på S-siden av Hornsund gikk Føyn og Mæland så langt som mulig Ø-over langs med stranden. Breene

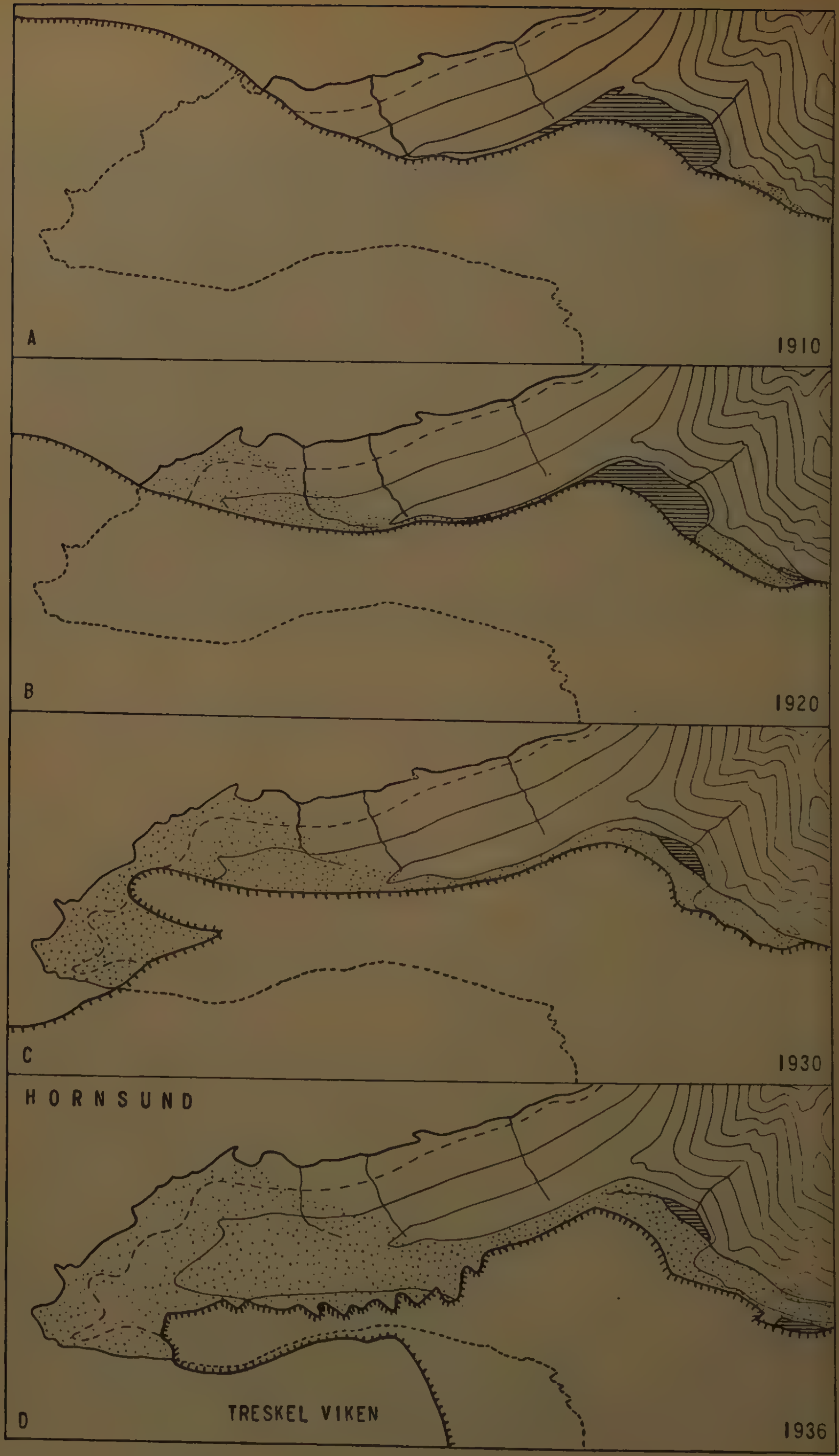

Fig. 17. Avsmeltning av isen fra Treskelodden. Rekonstruksjon av brefronter fra 1910 (A), 1920 (B), 1930 (C) og 1936 (D). Sammenlign med fig. 5.

her kalvet ikke lengere i havet, men de fleste hadde en mer eller mindre smal strimmel av land foran seg. Innerst i bukten, ikke langt fra fronten for den egentlige Hornbreen, fant så Føyn skjell av *Mya truncata* i de bekker som rant under breen, og delvis dannet grotter under isen.

Alt dette viser med all ønskelig tydelighet at en gang etter istiden må Hornsund ha vært meget mer isfri enn nå, og at i de områder som nå er dekket av isbreen, har det vært havområder hvor ovenfornevnte muslinger har levet i store mengder. De store skjellbanker ligger nå delvis på bunnen av havbukter, delvis muligens i strandterrasser forholdsvis langt inne i landet. De ble rotet opp av breene og transportert frem dit hvor breene tinet bort. Tross det at muslingene er meget godt bevart og tilsynelatende helt uskadde, er de altså blitt transportert et lengere eller kortere stykke vei, og delvis avsatt meget høyere oppe enn der hvor de virkelig har levet. Ved bedømmelse av forekomster av kvartære muslinger i Skandinavia bør man altså regne med den mulighet at de kan være transportert av isen langt bort fra sitt egentlige levested. En lokal muslingbanke, med tilsynelatende godt bevarte skjell, kan således ikke uten videre tjene som et sikkert bevis på at havet har stått så eller så høyt.

I det store og hele må man si at studiene på Spitsbergen av resente breer og deres avsmeltningsforhold utvilsomt må være av overordentlig stor betydning for kvartærgeologer.

SUMMARY

Some observations on the retreat of the glaciers in Hornsund, V. Spitsbergen

In the summer of 1949 the »Norsk Polarinstitutt« sent a geological party, consisting of Director, S. Føyn, Professor A. Heintz and two students, to Hornsund. Among other things we had an opportunity of studying the retreat of the glaciers in Hornsund. Hornsund has been visited earlier by several scientific expeditions, after which some more or less good maps of the district have been published (Austrian — 1872, Russian — 1899—1900, Norwegian — 1918, 1936, German — 1937—38). For my investigation I used besides these maps the topo-

graphical ones published by the Norsk Polarinstitutt (C 13, E 12) based on aerialphotographs.

In fig. 1 and 2 it can be seen that 6 glaciers open to-day into the inner part of Hornsund, and 2 at the end of Burgerbukta. In 1900 these 6 glaciers formed only one large glacier. Its front was situated about 6 kilometers farther to the W than it is now. On map fig. 2 one can see the gradual retreat of the glacier from 1900 to 1949. The area which became ice-free during these 50 years is about 30 square kilometers, and the masses of ice melted — amount to at least 3 cubic kilometers. This means that ca. 60 million m³ of ice melted on an average each year. The glaciers in Burgerbukta have also declined considerably during the same period.

The retreat of the glaciers in various parts of Spitsbergen is a well-known phenomenon. In Hornsund however it was possible to study in detail the retreat of the glacier from a tongue of land — Treskelodden — 4 km long and ca. 1 1/3 km broad (fig. 3, 5), which was completely covered by the Horn-glacier in 1900 and was entirely ice-free in 1949 (fig. 17).

Treskelodden is ca. 140 m high in its northern part and gradually declines to the south. A marked high ridge runs along its longitudinal axis (N — S), dividing the Treskelodden into a steeper western slope and a flater eastern one. Along this ridge we have discovered 3 empty creeks running towards the western beach. They have served during the time as an outlet for the melting water from the glacier (fig. 5).

Creek I is rather old. It starts about 115 m a.s.l. The part of the ridge between the Hyrnefjell and the creek shows no moraine-material. The vegetation is rich and only a few and indistinct glacial striae can be observed, running approximately E — W.

Between creeks I and II the picture has strongly changed. The vegetation here is scarce, the glacial striae are distinct and more abundant and still run from E to W. Parallel to the high-ridge between creeks I and II, but somewhat to the E, there is developed a long and relatively high moraine, composing a rather deep groove between itself and the high ridge. The melting-water from the glacier has flowed through this groove previously and found its outlet into creek II, which starts about 110 m a.s.l. and composes an immediate prolongation of the groove.

A relatively long, deep, but narrow lake was dammed up at that time by the glacier farther to the NE (fig. 17 A) and was limited from S and E by the Horn-glacier, which at that time was at least 60—70 m thicker here, from N and W — by the slopes of Hyrnefjell and Treskelodden. Here can be seen a very distinct but not broad terrace, about 110 m a.s.l., which marks the position of the lake-beach (fig. 6, 7). The overflow from this lake also ran through the above-mentioned groove and creek II (fig. 8).

Between the creeks II and III the high-rigde of Treskelodden is more or less completely covered with very fresh moraine-material and the vegetation is very scarce here. The glacial striae, seen in places where the solid rocks are exposed, run now in a more NNE — SSW direction. Creek III is fresh and deep. The melting-water from the glacier and also probably from the ice-dammed lake has flowed here, after the glacier had melted to such an extent, that creek II lay too high to serve as an outlet for the melting-water (fig. 17 B).

During a further decrease of the glacier creek III also became empty, and the melting-water ran more to SW and S. The south-western part of Treskelodden, especially the localities near to the beach, is covered with mud, sand, boulders etc., transported by the melting-water from the higher lying moraines. These deposits cover large portions of »fossil ice«, which one can see in many places below the terraces and in the creeks, etc., partly under thick layers of mud and sand (fig. 10).

The last part of the glacier, which reached the sea on the western coast of Treskelodden, covered the narrow, flat valley which is now limited on both sides by moraines (fig. 11). Here one can see a great deal of fossil ice. The glacier, which at that time covered practically only the eastern side of Treskelodden, was more or less »dead«. The ice-dammed lake was also empty — the water from it, after the glacier had become considerably thinner, ran to the SE, probably firstly over, finally under the remains of the glacier (fig. 17 C).

During the further reduction of the glacier the first trace of the Treskel-bay, situated to the E of Treskelodden, became visible. The ice, which covered the eastern slope of Treskelodden, melted rapidly, and the glacier which was still flowing, ran into the sea in the inner part of Treskel-bay (fig. 17 D).

In 1949 the glacier at the bottom of Treskel-bay was also »dead« (fig. 15). All the ice on the eastern slope of Treskelodden has disappeared and the landscape here shows a country which only recently has become ice-free (fig .9). Here one can see much fossil ice (fig. 13), mud-pyramids and ridges, which filled the cracks in the glacier (fig. 16), boulders, lots of brooks (fig. 12), etc. The Treskel-bay is now completely ice-free (fig. 5). One can see the narrow beach below the front of the glacier at the bottom of Treskel-bay (fig. 14) and on the western side of the bay the solid rocks are visible below the glacier, marking a new tongue of land running paralell to Treskelodden (fig. 9).

Both on the eastern and western side of Treskelodden, almost from creek II and southwards, many shells of marine molluscs were discovered in the moraine material. The most abundant were: *Chlamys islandica*, *Mya truncata*, *Astarte borealis* and *A. eleptica*, less in evidence were—*Saxicava arctica*, *Balanus*, *Buccinum* while *Litotamnium* were more common. The shells are found from the beach and upwards into the high-ridge of Treskelodden — about 100 m a.s.l. They were here especially abundant and well preserved and the right and left shells were still partly together. In no other parts of Spitsbergen have the elevated beaches or terraces with shell-deposits (*Mya* and *Mytilus*) been discovered higher up than 65—70 m a.s.l.; it is thus improbable that in Treskelodden we are confronted with marine deposits, the shells must have been transported to Treskelodden by the glacier from the bottom of the Treskel-bay or from another place farther E. At two other places in Hornsund, Dir. S. Føyn has actually found *Mya truncata* partly on the glacier and partly in cavities beneath the glacier.

TEXT-FIGURES

Fig. 1. Aerialphotograph of Hornsund from the E. (Norsk Polarinst. photo).

Fig. 2. Front of the Hornbre in 1900 (. . . : . .), 1918 (-·-·-), 1936 (———) and 1949 (- - - - - -).

Fig. 3. Treskelodden seen from N to S (A. Heintz photo).

Fig. 4. A cut from a Russian map of Hornsund (measured 1899-1900), with the outline of Treskelodden and Hyrnefjell drawn after the last Norwegian map (1952).

Fig. 5. Map of Treskelodden, after Norwegian map and observations in 1949.

Fig. 6. View from Treskelodden to NNE. The bottom and beach-terrace of the ice-dammed lake (A. Heintz photo).

Fig. 7. View from the end of the ice-dammed lake to NW. Beach-terrace. (A. Heintz photo).

Fig. 8. View from the beach-terrace of the ice-dammed lake to S (A. Heintz photo).

Fig. 9. View from the high-ridge of Treskelodden to ENE. Moraines. (A. Heintz photo).

Fig. 10. The W-shore of Treskelodden. Fossil ice below the terrace (A. Heintz photo).

Fig. 11. S-part of Treskelodden. The valley through which the last portion of the glacier reached the W-shore. (A. Heintz photo).

Fig. 12. The E-shore of Treskelodden (A. Heintz photo).

Fig. 13. Fossil ice. E-part of Treskelodden (A. Heintz photo).

Fig. 14. End of the Treskel-bay with front of the »dead« glacier. (A. Heintz photo).

Fig. 15. Front of the »dead« glacier at the end of Treskel-bay. (A. Heintz photo).

Fig. 16. The E-shore of Treskelodden. Mud-ridges and pyramids. (A. Heintz photo).

Fig. 17. Front of the Hornglacier in relation to Treskelodden in 1900 (A), 1920 (B), 1930 (C), and 1936 (D). Compare with fig. 5.

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THE MIDDLE ORDOVICIAN OF THE OSLO REGION, NORWAY

1. Introduction to Stratigraphy.

BY

LEIF STØRMER

assisted by

A. Heintz, G. Henningsmoen, S. Skjeseth and N. Spjeldnæs.

With 6 plates and 16 figures in the text.

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Abstract: The present paper is the first in a series dealing with the stratigraphy, paleontology and tectonics of the Middle Ordovician of the Oslo Region, the latter comprising 11 districts located between Langesund and Ringsaker. The term Middle Ordovician is discussed. The sequence of the Oslo Region favours a lower boundary either below the Upper Didymograptus Shale (base of *bifidus* zone, 4a α_1) or below the Ampyx Limestone (base of *gracilis* zone, 4a β), boundaries corresponding to the base of Llanvirn and Caradoc respectively. An upper boundary is suggested below the Lower Tretaspis Shale = zone of *Tretaspis seticornis* (4c α).

A historical review deals with the different periods in the paleontological-stratigraphical investigation of the Middle Ordovician in the Oslo Region.

A survey of the Middle Ordovician section based to a large extent on new observations by Heintz (= Hz), Henningsmoen (= Hm), Skjeseth (= Sk), Spjeldnæs (= Sp) and the present author (= St), is presented. Each district is treated separately. The large fossil collections accumulated through more than 100 years will be described eventually. Thanks to determinations of the graptolites by Dr. Bulman, Cambridge, England, it has been possible to date most of the zones. The Orthoceras Limestone (3c α—γ) seems to be equivalente to less than one graptolite zone only, i.e. the zone of *Didymograptus hirundo.*

Considerable variation in facies occurs, ranging from black graptolite shale, mixed graptolite and trilobite shale, shale, occasionally strongly arenaceous, with shelly faunas, limestone with shelly faunas, to algal and coral limestone, including reefs. Local emergences have been traced and certain general paleogeographic features outlined.

The Oslo-section is preliminarily correlated with sections in Sweden and the Baltic. A more detailed correlation is postponed until the major fossil groups are described.

Introduction.

With the aid of grants from The Norwegian Research Council for Science and the Humanities, the Paleontological Institute and the Paleontological Museum of the University in Oslo have initiated a more detailed study of the Middle Ordovician of the Oslo Region. Through more than a hundred years extensive fossil collections have been gathered from the shales and limestones of this region, more than 400 trays with fossils are preserved in the Paleontological Museum. Most of these fossils are, however, not described. Both the late professor W. C. Brøgger and professor J. Kiær planned to do so, but other work laid claim to their time.

The present studies are not limited to the paleontological description of the fossils. Stratigraphical and tectonic investigations have to be added in order to obtain a more complete information regarding the general appearance both of the fossils and the sediments in which the fossils occur.

The Lower Paleozoic of the Oslo Region deserves considerable interest in many ways since it forms an intermediate development between thick geosynclinal sedimentary series of great Britain and the Trondheim Region of Norway (Vogt 1945), and the thin epicontinental series of the Baltic. The Oslo-series contains both shales and limestones and the alternation, at least to some extent, of graptolite and shelly facies makes it more possible to correlate western and eastern sequences.

In the present research the following take part: professor A. Heintz, curator G. Henningsmoen, cand.real N. Spjeldnæs, cand. real. S. Skjeseth and the present author. Besides these more permanent members, curator J. Dons is effecting tectonic work of general interest to our subject. Most of the fossils will be described by those mentioned above, but some groups will be described by foreign specialists. The Middle Ordovician corals are described by Dr. Dorothy Hill (1953), Melbourn, Australia, certain trilobites (Styginidae) by Skjeseth (1953 b) and ostracods by Henningsmoen (1953).

Conserning the field work, it has become appropriate to divide the Oslo Region into a number of separate districts as shown in fig. 1. The division is merely arbitrary, not based on marked differences in geological structures. A division into districts (of which some have practically no Ordovician) has proved itself useful for museal purposes. As mentioned below the northern limits of the Oslo Region are somewhat uncertain. The Ordovician occurrences in the Snertingdal and on Hedmarkvidda lie distinctly outside the Oslo Region, but an outside position may possibly be claimed also of the Ringsaker District (11).

The Langesund District (3) is being studied by Henningsmoen, the Eiker (4) by Heintz, Oslo—Asker (1) and Holmestrand (2) by

Spjeldnæs, Modum (5), Ringerike (6) and Hadeland (7) by Størmer, and Feiring (8), Toten (9), Nes—Hamar (10) and Ringsaker (11) with the adjacent lying districts of Snertingdal and Hedmarkvidda, by Skjeseth.

The field work was concentrated on the collecting of fossils from the various beds and on the obtaining of representative sections of the stratigraphical sequences within each district. Special stress has been laid on the occurrences of facial variation, a point which seems to be of special interest in connection with the determination of major tectonic overthrusts. In connection with the tectonic studies more detailed geological mapping of certain areas has become necessary. The mapping has to a large extent been based on aerial photos.

Considerable field-work has previously been accomplished by Brøgger, Kiær, Holtedahl and others. Their unpublished notes have been used as far as possible, especially when they offer information about localities no longer accessible.

It became apparent during the work that detailed stratigraphy could not be effected without a thorough and up-to-date study of the fossils. To postpone the stratigraphical studies until all the fossil groups are eventually described seems, however, little desirable, and a description of the fossil forms are, on the other hand, not easy without a general stratigraphical scheme. We find it therefore useful to present a preliminary stratigraphical scheme which may prove useful both to the paleontologists and to further stratigraphical studies.

Thus the scope of the present paper is to present an introduction to the general stratigraphy of the Middle Ordovician in the various districts of the Oslo Region. The information given is based chiefly on new observations and collections by Heintz, Henningsmoen, Spjeldnæs, Skjeseth and the present author. When referring to new observations in the text, I have as far as possible quoted the contributors by using abbreviations of their names: Hz = Heintz, Hm = Henningsmoen, Sk = Skjeseth, Sp = Spjeldnæs, and St = Størmer.

Dr. O. M. B. Bulman of Cambridge, England, has been kind enough, during a visit here in Oslo, to give a preliminary determination of our Middle Ordovician graptolites. These determinations and his ascertainments of the different graptolite zones have been of great help in fixing a general stratigraphical skeleton. I wish to express to Dr. Bulman our warmest thanks for this valuable contribution to our work on the Middle Ordovician stratigraphy. We are also indebted to fil.lic. V. Jaanusson of Uppsala, for the determination of certain asaphids. The brachiopods and ostracods are preliminarily determined by Spjeldnæs and Henningsmoen respectively.

No work on the sedimentary petrology has been carried out yet. In describing the sediments, the common terms such as ”shales, limestone, arenaceous limestone” have been used. More detailed petrological studies of the sediments will probably show that other designations are more correct.

In the present introduction which will appear as No. 1 in the series: ”The Middle Ordovician of the Oslo Region, Norway”, the previous research is dealt with more extensively in a special chapter on a historical review.

Future papers in the series are chiefly planned to comprise paleontological descriptions as well as stratigraphical — tectonic descriptions of each district. In a final paper the stratigraphical correlations will be treated in a more detailed manner.

My sincere thanks are due to Miss Randi Gulliksen, Miss Bergljot Mauritz and Miss Lily Monsen for valuable technical assistance in the preparation of the present paper.

The term Middle Ordovician.

A tripartition of the Ordovician System does not seem to be a well established fact or at least it does not seem to be well defined in accordance with the international zonal division of the Ordovician. Apparently different and less distinct conceptions exist concerning the term ”Middle Ordovician”.

In this country, Kiær (1920 p. 116) included parts of the Ogygiocaris Shale in the Lower Ordovician. The Upper Didymograptus Shale (4a α_{1-2}) was evidently regarded as belonging to the Lower Ordovician, while the younger Ogygiocaris Beds (4a α_{3-4}), as well as the Ampyx Limestone (4 a β) and the Chasmops Beds (4b α—δ) were considered as representing the Middle Ordovician.

In Sweden Regnéll (1945 p. 63) arbitrarily restricted the Lower Ordovician to comprise the Ceratopyge Series, and the Middle Ordovician the Asaphus and Chasmops Series. This evidently means that the lower boundary of the Middle Ordovician is drawn below the Lower Didymograptus Shale (3b).

In Great Britain, Bulman (1938 p. D 61) like Kiær, regards the Llanvirn (Upper Didymograptus Shale) as the upper part of the Lower Ordovician. One has to bear in mind, however, that in England the Tremadoc (Ceratopyge Series) is generally included in the Cambrian, a fact which may cause a fairly high boundary of the Lower Ordovician.

In U.S.A., Raymond (1916), when treating the Balto-Scandinavian sections, drew the line below the Upper Didymograptus Shale (4a α_1).

In order to come to a preliminary conclusion concerning the lower and upper boundaries of the Middle Ordovician, it is necessary to consider the development of the transition series in Norway.

The Lower Didymograptus Shale (3b) (= Phyllograptus Shale of authors) rests on the Ceratopyge Limestone (3a γ) forming the uppermost zone of the Ceratopyge Series (2e—3a γ). The Lower Didymograptus Shale was divided by Monsen (1938) into four subzones (probably zones) of which the uppermost one (3b δ) with *Phyllograptus angustifolius elongatus* is regarded as forming the top of the shale. Recent studies (Sp) have meanwhile suggested the presence of a still higher zone below the Orthoceras Limestone, a zone which is segregated here as the zone of *Didymograptus hirundo* (pars) (3b ε) (p. 116). Evidently only the lower part of this British zone is present.

The Lower Didymograptus Shale is succeeded, with rapid change in facies, by the Orthoceras Limestone (3c). It may be mentioned, however, that the upper zones of the 3b in the Ringsaker district also show a limestone development with a trilobite facies (Skjeseth 1952). The Orthoceras Limestone of the Oslo type consists of a basal Megalaspis Limestone (3c α) with a thickness of 1—1,5 m, a median Expansus Shale and Limestone (3c β) 3—5 m, and an upper Orthoceras Limestone (3c γ) of 2.5—4 m. The name "Orthoceras Limestone", even with s. str. added to it, is not fortunate because it is apt to be confused with the name "Orthoceras Limestone" meaning all three zones. The latter name, sometimes used with s.l. added, has to be maintained since a tripartition of the limestone is sometimes missing. A new designation for the upper zone would be useful. Characteristic of the zone are the very numerous specimens of endoceratids belonging to such genera as *Cyclendoceras* and *Vaginoceras*. Although the genus *Endoceras* is hardly present, the name Endoceras Limestone is suggested here as a substitute for Orthoceras Limestone s. str. (3c γ).

"Expansus Shale" is not a fortunate name either. *Asaphus expansus* is only characteristic of the uppermost beds (1 m) of the 3c β and the same species also seems to occur commonly in the lower part (1 m) of the Endoceras Limestone (3c γ). Characteristic of 3c β are the different species of the genus *Asaphus*, species which may appear to serve as index fossils for different subzones. For this reason the name Asaphus Shale is suggested as a substitute for Expansus Shale and Limestone (3c β).

The tripartite division of the Orthoceras Limestone is chiefly based on the lithology (Brøgger 1882). It may be mentioned that the index fossil *Megalaspis limbata* occurs both in 3c α and 3c β. A future, more detailed paleontological division of the Orthoceras Limestone may not coincide with the present division based on the lithology.

Concerning the Endoceras Limestone (3c γ) Brøgger (1882 p. 25) distinguished a lower part (1 m), the so-called *Porambonites* Beds with a fauna similar to that of 3c β. The upper part contains besides the cephalopods, *Megalaspis grandis* a.o. The uppermost beds with *Megalaspis gigas* are also included in Brøgger's 3c γ. As shown below the compact Endoceras Limestone may be succeeded by shale and limestone with a transitional fauna pointing both to the Orthoceras fauna below and the Ogygiocaris fauna above. In certain districts *M. grandis* and *M. gigas* distinguish succeeding beds above the typical Endoceras Limestone. We were first inclined to segregate these as separate zones or subzones, but afterwards came to the conclusion that a detailed division of the Endoceras Limestone (3c γ) must be postponed until the whole Orthoceras Limestone has been subjected to more detailed studies.

Above the Orthoceras Limestone there is found the characteristic Upper Didymograptus Shale (4a α_{1-2}). Recent finds have shown that the lower part of the shale belongs to the zone of *Didymograptus bifidus* (4a α_1), the zone succeeding the *D. hirundo*-zone of the British graptolite section.

Further up there are the typical *Ogygiocaris* beds (4a α_3), the *bronni* zone (4a α_4) and eventually the Ampyx Limestone (4a β). As discussed below (p. 122), the transition between the *bronni*-zone and the Ampyx Limestone includes breaks at certain parts of the Oslo Region.

In the Oslo Region it might seem natural to draw the lower boundary of the Middle Ordovician either at the base of Upper Didymograptus Shale corresponding to the base of the *Didymograptus bifidus*-zone (4a α_1), or at the base of the Ampyx Limestone corresponding to the base of the *Nemagraptus gracilis* zone (4a β).

In favour of the first choice the lithological change between the Orthoceras Limestone and the overlying black shale, the Upper Didymograptus Shale might be mentioned. The line of division also marks a horizon of upheavals and unstable conditions. Faunistically, the boundary coincides largely with the first abundant occurrence of biserial graptolites and the first appearance of cryptolitids so characteristic of the Middle Ordovician. It also coincides with the lower boundary of the Ogygiocaris Series, a designation introduced in this paper after a suggestion made by Henningsmoen.

The second possibility also involves a lower boundary corresponding to the termination of an unstable period with local uplifts. The line of division marks the appearance of the characteristic *Reedolithus*-fauna and has also the advantage of corresponding to the lower boundary of the Chasmops Series in Norway (*Chasmops* not actually appearing until the upper part of 4a β.)

At present I am inclined to prefer the first alternative, which also seems to give a better balance to the division of the Ordovician and corresponds to the boundary between the Arenig and Llanvirn in Great Britain. If a final decision has to be made it would be desirable to do so in agreement with other workers in the field as suggested to us also by Fil.lic. Jaanusson at Uppsala. In the present paper the sediments above the *bifidus* zone are preliminarily included in the Middle Ordovician.

The upper boundary of the Middle Ordovician seems more easy to establish in the Scandinavian countries. The thick limestones at the top of the Chasmops Series (Upper Chasmops Limestone 4b δ, Encrinite- and Mjøsa Limestones) form natural terminations of the Middle Ordovician in these countries. Between the limestone and the black Lower Tretaspis Shale (4 c α) above, a hiatus generally appears to be present, and this hiatus is much more pronounced in the northern districts where the Middle Ordovician limestone (4b δ)

is succeeded by Lower Silurian beds. The Lower Tretaspis Shale or zone of *Tretaspis seticornis* (4c α) evidently corresponds to the zone of *Pleurograptus linearis*, a fact which involves our upper boundary of the Middle Ordovician lying below the upper boundary of the Caradoc and thus does not correspond to the upper boundary of the Middle Ordovician of Great Britain.

The following zones are provisionally included here in the Middle Ordovician of the Oslo Region: The Upper Didymygraptus Shale (4a α_{1-2}), the Ogygiocaris Shale (4a α_3), the *bronni* Beds (4a α_4), the Ampyx Limestone (4a β) and the Chasmops Shales and Limestones (4b α—δ). The division provisionally used in this paper may be illustrated as follows:

Upper Ordovician	Tretaspis Series[1]	Ashgill
Middle Ordovician	Chasmops Series	Caradoc
	Ogygiocaris Series	Llandeilo Llanvirn
Lower Ordovician	Asaphus Series	Arenig
	Ceratopyge Series	Tremadoc

Historical review.

The fossiliferous shales and limestones of the Oslo Region early attracted the attention of Norwegian and foreign scientists. Leopold v. Buch (1810) and Hausmann (1811, 1812) travelling in Norway in the early years of the last century, both mention the many occurrences of fossiliferous sediments from the "Übergangsgebirge".

A more detailed and regional survey of the sedimentary rocks was carried out by Esmark (1829) and Keilhau (1826, 1838), the early professors in geology at the University of Oslo. Esmarck and Keilhau, however, chiefly described the Cambro-Silurian sediments from a petrological point of view. They mention the alum shales as belonging to the base of the sequence, but otherwise give no information about the stratigraphy. Keilhau who published a very good geological map of the Oslo Region, noticed the prevailing northern dip of the strata and deduced erroneously the presence of a more or less continuous sequence of great thickness without folds (except smaller ones in connection with the faults).

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[1] Including the Isotelus Series, thus comprising the zones 4 c α — 5 a.

A following period dating around the forties, was devoted to descriptions of the fossils. Already in 1781 Brünnich had described a trilobite (*Ogygiocaris dilatata*) from the Langesund? district, and in 1784 Strøm figured Ordovician fossils from Eiker (Eger). More systematic discriptions of Norwegian trilobites appeared about fifty years later by H. M. T. Esmarck (1833), Sars (1835) and Boeck (1838) (comp. Størmer 1940), and several species were also described by the Swedish paleontologists Dalman (1826) and Angelin (1851, 1854). Graptolites of the Oslo Region became known through the works of Boeck (1851) and Scharenberg (1851).

A third period in the geological survey of the Oslo Region was introduced in 1844 when the famous British geologist Sir R. E. Murchison (1847) paid a visit to Oslo (Christiania) during a meeting of Scandinavian scientists. On an excursion in the vicinity of Oslo he was struck by the striking similarity in stratigraphy and tectonics between the Oslo Region and Wales in the British Isles. Murchison was the first to realize the presence of a comprehensive folding of the sediments in the Oslo Region. He also visualized the possibility of establishing a more detailed stratigraphical division based on characteristic fossils.

Th. Kjerulf, at that time a young geologist at the University of Oslo, was quick to grasp these new and highly inspiring views. Murchison strongly urged both Kjerulf and D. Forbes, at that time leader of the Apatite mine in Kragerø not far from Langesund, to study in detail the stratigraphy of the Cambro-Silurian beds of the Oslo Region. Kjerulf (1855, 1857) concentrated his studies mainly on the Oslo district, while Forbes (1856) and with him T. Dahll, worked on the Skien—Langesund section.

Kjerulf (1855) was able to prove that Murchison was right in explaining the apparent great thickness of the sediment at Oslo as being due to a constant repetition of the strata through folding. Forbes (1856) was able to distinguish the major stratigraphical units in the unfolded sedimentary complex of the Langesund district.

In his important paper: ”Ueber die Geologie des Südlichen Norwegens” Kjerulf (1857), with contribution by Dahll (1857), laid the foundation of the Lower Paleozoic stratigraphy of this country. Kjerulf divides the Ordovician, including parts of the Cambrian and Silurian, into two major groups named after the type localities:

Oscarshall Group	5 *α*,	Calcareous sandstone
	4,	Calcareous shales and marls with first crinoids.
Oslo Group	3 *β*,	Upper graptolite shale.
	3 *α*,	Orthoceratite limestone.
	2	Alum shale and Lower graptolite shale.

Stage 2 comprises the Upper Cambrian alum shales (2a—d) as well as the Ceratopyge Series (2e—3a) and the Lower Didymograptus Shale of the Ordovician. Stage 3 *α*—*β* apparently represents the Orthoceras Limestone s.l. (3c) and the Upper Didymograptus Shale (4a *α* lower part) and apparently also the Ogygiocaris Shale (4a *α* upper part). The division line between 3 *β* and 4 is not clearly defined and due to insufficient labelling of earlier finds, the fossil lists form to some extent a mixture of different faunas. Thus *Chasmops conicophthalma* is referred to stage 3, while *Asaphus expansus* is said to belong to stage 4. The placing of *Chasmops conicophthalma* in the Orthoceras Limestone was probably due to a certain mixing of *Pterygometopus sclerops* and the above mentioned species.

For the Langesund—Skien district, Dahll presents the following divisions:

Stage 5a	Venstøb or Herøy Limestone
Fossum group: stage 4 *α*	4b Venstøb Shale
	4a Impure grey limestone and intermittant shale. (Fossum Limestone).
Stage 3	Shale with *Asaphus* [*Ogygiocaris*] *dilatatus* and upper graptolites.
	Blue-grey Limestone (Orthoceras Limestone).

The Fossum Limestone is evidently identical with the Encrinite Limestone and the Venstøb shale with the black Tretaspis Shale.

Kjerulf also tried to correlate his stratigraphical divisions with those presented by Angelin (1851—54) for Sweden a few years earlier. Angelin's descriptions and references to Norwegian fossils were of course of great help to Kjerulf in his stratigraphical determinations.

The results obtained by Kjerulf soon attracted the interest of foreign geologists. Murchison (1858) was particularly pleased with Kjerulf's inclusion of the alum shales in a common group with the graptolite shale, a grouping which Murchison regarded as a confirmation of his view on the alum shale belonging to his Silurian.

Ferdinand Roemer, the well-known paleontologist, also became interested and in 1859 visited the Oslo Region where Kjerulf and Dahll took him around on several excursions. Roemer (1859) discusses Kjerulf's stratigraphical divisions and doubted the justifications of the two groups on the grounds that several fossils seemed to be common to both groups according to the lists presented by Kjerulf. This, however, referred chiefly to the above mentioned mistakes in the lists.

Three smaller papers by Kjerulf (1862 a, b, c) dealt with the distribution of the Ordovician rocks in the Oslo Region.

In 1865 appeared Kjerulf's guide to geological excursions in the neighbourhood of Oslo (Kristiania). The fossils, of which a few are new, are treated stratigraphically, with references and some illustrations. The Oscarshall- and Oslo Groups are abandoned in favour of a stage-division. *Chasmops conicophthalma* is now transfered to stage 4, but *Echinosphaerites*, characteristic of the top layers of the Ampyx Limestone (4aβ), is still placed in stage 3. The term "Chasmops Beds" was introduced by Kjerulf.

The valuable work of Kjerulf was continued by his successor at the University, W. C. Brøgger. Brøgger evidently intended to describe both stratigraphically and paleontologically the whole Cambro-Silurian sequence of the Oslo Region. He started with the Cambrian and his work on Stage 2 and 3 has become classical (Brøgger 1882). His further studies on the Middle and Upper Ordovician, stage 4, were interrupted, however, by his appointment to a professorship in Stockholm, and by his growing petrological interests. Fortunately he found time to publish an important paper on the stratigraphy and tectonics of the Cambro-Ordovician sediments of the Langesund districts (1884) and another on the stratigraphy of the Middle and Upper Ordovician of the Oslo District (1887). In his Langesund paper the work of Forbes and Dahll was greatly extended and in addition to a detailed stratigraphical description a correlation with the Baltic was attempted. In his Oslo paper the Middle and Upper Ordovician is divided into a number of zones designated as subdivisions of stage 4. This division has become classical and later authors have, as far as possible, tried to maintain this division although it is based more on petrological characteristics than on the fossil assemblages.

The stratigraphical studies introduced by Kjerulf and continued by Brøgger were carried on by Bjørlykke (1905) and by Holtedahl (1909) in his paper on stage 4 at Mjøsa. In addition to the fossil lists and descriptions of sections, Holtedahl gives certain petrological analyses of the sediments and discusses the regional distribution and transport of the material building up of the sediments. In a paper on the limestone occurrences in the Oslo Region the same author (Holtedahl 1912) also deals with the Middle Ordovician sediments.

In 1914 P. C. Raymond and W. H. Twenhofel from U.S.A. visited the Oslo Region after having visited the Baltic and parts of Sweden. In his valuable report of the expedition, Raymond (1916) also introduces new and fruitful views on the stratigraphy of the Oslo Region. He assumes a major hiatus between the Upper Chasmops Limestone and the Lower Tretaspis Shale, and regards the Mjösa Limestone as Middle Ordovician.

Extensive studies of the Middle Ordovician were carried out by J. Kiær, professor of historical geology and paleontology at the University of Oslo. Like Brøgger, Kiær intended to describe the Middle Ordovician of the Oslo Region. Other work, however, particularly the description of the Downtonian vertebrates from Ringerike near Oslo and Red Bay in Spitsbergen took most of the time in his later years. His extensive collections are meanwhile preserved in the Paleontological Museum and many of his observations are available in his note-books.

Kiær adopted and confirmed Raymond's idea of a considerable hiatus at the top of the Middle Ordovician. His results are based on new stratigraphical and paleontological observations (Kiær 1920, 1921, 1922, 1926). In the Paleontological Museum of the University Kiær introduced experimentally a new stage division (quoted by Funquist 1919) which, however, has been little used later on.

Frebold (1928) discusses the alternation of shale and limestone in the Middle Ordovician section.

Local stratigraphical descriptions, mostly in connection with geological mapping of the Oslo Region, have been given by Bjørlykke (1898), Werenskiold (1911), Holtedahl and Schetelig (1923), Grorud (1940) and Størmer (1945). A brief review of the stratigraphy was presented by the latter author (1934).

From time to time paleontological descriptions of the Middle Ordovician fossils of the Oslo Region have been published. The earliest ones have already been mentioned. In the following review it has also been attempted to quote foreign papers in which material from the Oslo Region is described.

Fossil calcareous algæ were described by Kiær (1920) and Høeg (1927) and corals by Kiær (1897, 1930). The gastropods were dealt with by Koken and Perner (1925) and certain cephalopods described by Holm (1885) and Strand (1933), the latter dealing chiefly with the Upper Ordovician cephalopods of the Oslo Region. Holtedahl (1916) described the brachiopods belonging to the Strophomenida (Öpik limited his studies in Norway to the Lower Ordovician and beds younger than the Middle Ordovician).

With regard to the trilobites, Lindström published a new edition of Angelin's Paleontologia Scandinavica (Angelin 1878a), and Brøgger (1886) described the hypostoma of the Asaphidae. The Trinucleidae (Cryptolithidae) being dealt with by Størmer (1930) who also recorded early descriptions of Norwegian trilobites (1940, 1943a), Lichids by Warburg (1939), certain Raphiophoridae by Whittington (1950) and Asaphidae by Jaanusson (1953). Some ostracods were described by Dons and Henningsmoen (1950). Pelmatozoans of the Oslo Region have been treated by Angelin (1878b), Jaekel (1899 and 1926) and Regnéll (1945). Graptolites were described by Holm (1881), and recently by Decker (1951).

Paleontological descriptions are also included in some of the stratigraphical papers previously mentioned. Stratigraphical correlations have been suggested by many authors, but since a more detailed correlation is dealt with in a future paper, references are not given in the present review.

The sections of the Oslo Region.

The Caledonian Geosyncline with its thick series of Eocambrian and Cambro-Ordovician sediments forms the western boundary of the large Fenno-Scandian Shield of northern Europe. Eastwards this Precambrian window is concealed under the flat-lying Early Paleozoic sediments of the Russian Platform.

In the western part of the Fenno-Scandian Shield, in southern Sweden and southeastern Norway, the Precambrian Shield is interrupted by patches, or areas of Early Paleozoic, Cambro-Silurian, sediments resting on the Precambrian Platform. The areas are generally bounded by vertical faults, at least on certain sides, and thus form subsided areas or grabens.

The largest and most western of these subsided areas, is the Oslo Region. This region differs from the other areas in having experienced a comprehensive Permian igneous activity, a feature which has contributed to a considerable extent towards the formation of this particular region.

As shown on the map (fig. 1) the Oslo Region forms a narrow strip of land reaching from the Langesund district in the SSW to the Ringsaker district in the NNE, comprising a more or less rectangular area of about 220 × 45 km. As discussed below the northern limit of the Oslo Region is not clearly defined, but might perhaps be drawn along the northern side of the Precambrian horst (Sk.).

From the surrounding Precambrian rocks the Oslo Region is bordered either by Permian faults or merely by erosion of the sedimentary series which cover the Precambrian peneplane dipping towards the central districts.

The major part of the Oslo Region is occupied by Permian intrusives and lavas. The Cambro-Silurian sediments are chiefly confined to the fertile districts at Oslo, in Ringerike and Hadeland and on either side of the Mjøsa lake. More resistant sedimentary rocks, hardened through contact metamorphism, are preserved around the large intrusive bodies.

With an exception of the districts S of the City of Drammen, the Cambro-Silurian sediments have been subject to Caledonian folding with the folds showing a trend towards E or ENE. The intensity of the folding increases northwards, major overthrusts probably appear already at Ringerike (Stubdal), but are more significant in the Mjøsa area where the Cambro-Silurian of the Ringsaker appears to be typically allochthoneous (Sk.). The intensity of the Caledonian orogenetic movements increases gradually northwards towards the axial belts of the mountain range. It is therefore difficult to determine the northern border of the Oslo Region. The border may either be drawn north of the horst at the southern boundary of the Ringsaker allochthone, or further north where a more complete series of Eocambrian Sparagmite Series appears.

In order to facilitate the collection and storage of the fossils it has been found useful to divide the Oslo Region into a number of districts such as demonstrated in fig. 1. A division might either be strictly geological or based on regional and more practical features.

There are geological features, both stratigraphical and tectonic, which might justify a division based on the geology. The facies naturally varies within the Oslo Region. In his comprehensive study of the Silurian Kiær (1908) was able, in large features, to distinguish a western and eastern facies. A somewhat similar division of the Ordovician was suggested by Holtedahl (1909) and has recently been confirmed and elucidated by Skjeseth (1953 a) in connection with his studies on the Lower Didymograptus Shale (3b). Already Bjørlykke (1905) had noticed a change in facies towards N.

A tectonic division of the Lower Paleozoic Series would have to follow W—E (WSW—ENE) rather than N—S (NNE—SSW) lines. A considerable shortening or piling up of the sediments took place during the folding and thrusting. More rapid changes in facies would therefore be apt to occur when passing northwards through the Oslo Region. Abrupt changes in facies of this kind occur in Hadeland and in the Mjøsa area.

Although a purely geological division of the sediments in the Oslo Region might be accomplished, a more regional and less geological one seems more practical, chiefly for museal reasons. The division suggested in fig. 1 is to a large extent artificial, but has proved useful both in the field work and in the museum.

In the following, brief descriptions are given of the Middle Ordovician section within each district. (Certain districts have practically no Middle Ordovician, but the division into separate districts has also been made to satisfy other Lower Paleozoic series).

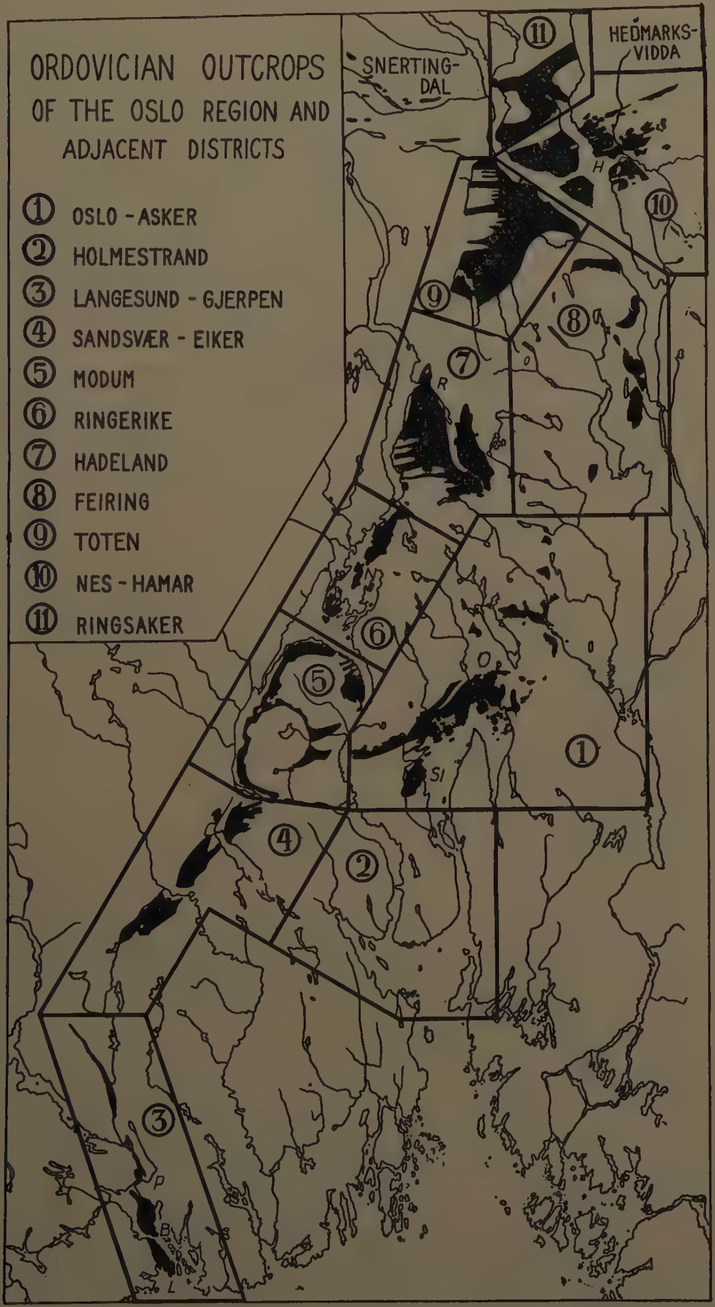


Fig. 1. Districts of the Oslo Region. Ordovician outcrops black. B = Brevik, H = Hamar, L = Langesund, N = Norderhov, O = Oslo, P = Porsgrund, R = Røykenvik, Sl = Slemmestad.

Local facial variations within each district are but slightly dealt with in the following review.

As far as possible a uniform division into zones (or subzones) is attempted. The stages and sub-stages were originally based on the Oslo development which therefore serves as type section. In the future it may be necessary to choose one particular exposure as type section. Brøgger's zonal division was based more on lithology than on fossils. This involves his minor divisions being possibly proved to be of a very different value. Thus his 4a α in fact represents several separate zones forming together a separate series, while a zone like 4b β evidently represents a much shorter space of time.

In order to avoid the least cause for confusion, the stage division of Brøgger is maintained as far as possible. It has been necessary only to introduce certain subdivisions of the minor divisions given by Brøgger.

1. THE OSLO—ASKER DISTRICT.

The Middle Ordovician of this district occupies a large part of the City of Oslo as well as the lowland and the islands stretching westwards through Bærum, Asker and Røyken and southwards in the Bunnefjord. Good exposures are found in the road- and railway sections, and along the shore-lines, particularly on the many islands. On account of the many exposures it is possible to obtain a large number of sections and thus an impression of detailed facies variation. Because of the folding, however, larger continuous sections are difficult to obtain. The soft shales are rarely preserved in their original thickness.

The City of Oslo (= Christiania = Kristiania) and its neighbourhood were the classical grounds of research in the Oslo Region. The pioneer work of Kjerulf and Brøgger has been emphasized above, but since then our knowledge and our fossil collections have been considerably increased by the investigations of K. O. Bjørlykke, J. Kiær, O. Holtedahl, W. Werenskiold, Th. Vogt, A. Heintz, T. Strand, v. Weymarn, J. F. Grorud, G. Henningsmoen, S. Skjeseth, N. Spjeldnæs, L. Størmer a.o. In the present research the detailed investigation of the district has been taken over by N. Spjeldnæs. Local tectonic studies are carried out by J. Dons at Slemmestad, Røyken.

The basal transition beds (*3c γ*). The transition from the compact Endoceras Limestone to the black Upper Didymograptus Shale is subject to variation within the district. At Toje, Slemmestad, Røyken, the upper part of the Endoceras Limestone (3c γ) contains endoceratids and the trilobites *Megalaspis grandis* and *Asaphus striatus*. At the top there is about 1.10 m of arenaceous limestone with grey shale with limestone nodules. The arenaceous limestone is partly packed with asaphid fragments. Fil.lic. Jaanusson has kindly examined the specimen which he is inclined to recognize as belonging to a species occurring in the *Megalaspis gigas*-zone in Sweden. The accumulation of asaphid shells is not found at Gjeitungholmen where the thickness of the transition beds is only 0.5 m (Sp.).

In Oslo (Killingen, Vekkerø) the transitional beds consist og about 1 m of sandy dark limestone containing dark phosphatic nodules and weather to a characteristic brownish colour. The beds occur above the compact limestone with stylolites up to 15 cm deep in the upper part.

In the eastern part of the city the transition beds have more the character of a nodular limestone bed, partly with asaphid fragments (Sp.).

The Upper Didymograptus Shale (*4a α_{1-2}*). Because of tectonic disturbances the graptolite shale above the Endoceras Limestone has often been subject to prismatic jointing which impairs the chances of a satisfactory preservation of the fossils. It is also difficult to establish the exact thickness of the zones.

At Oslo (Killingen N) the brownish transitional beds are succeeded by black shale with grey streak. The shale may have thin greyish beds and thin arenaceous limestone laminæ (about 1 cm) wedging out laterally. The lowest 2 m has practically no limestone lenses. Upwards the limestone lenses become more common. At about 8—10 m characteristic large (up to about 0.5 m) round lenses occur which weather to a yellowish-brown colour, and often interesected by calcite veins. The lenses, which are generally without fossils, consist according to Brögger of fine-grained lighter and darker bluish-grey limestone, partly arenaceous (Sp.). Pyrite concretions are common. Higher up (Huk) the round yellow lenses are replaced by flatter ones and when the *Ogygiocaris* beds (4a α_3) are reached, the lenses weather grey, a colour common to most limestone beds of the Middle Ordovician in the Oslo district.

In the classical section of Huk, Bygdøy, the lower part (11 m) of the shale is not exposed. Since graptolites of the *Didymograptus geminus* zone are found at the very base of the exposed section (11.5 m above 3c γ), it is probable that the section is not greatly disturbed. The thickness of the Upper Didymograptus Shale below the *Ogygiocaris* beds amounts to about 32 m.

North of Slemmestad, the Upper Didymograptus Shale is well exposed at several localities. A more or less continuous section through 4a α is found at the Eternite factory (Sp.). The lower part, about 10 m, is developed as black or grey shale, the upper part arenaceous and rich in mica. At 18 m arenaceous beds or large arenaceous lenses, or a combination of both, appear. The thickness of the sandy beds is about 6 m. They are succeeded by about 25 m of black shale with round lenses weathering yellowish-brown. The total thickness of the Upper Didymograptus Shale at Slemmestad thus amounts to about 49 m.

Fossils occur in the shale, in the pyrite concretions and as exceptions in the limestone lenses. The fossils preserved in the shales are graptolites and occasionally a few brachiopods, in the pyrite concretions and lenses gastropods and small cephalopods occur.

The best fossil section is found near to the Eternite factory at Slemmestad, Asker (Sp.). About 2.20 m above the Endoceras Limestone (3c γ) occur: *Phyllograptus nobilis* and *Didymograptus obscurus*(?) signifying the *Didymograptus bifidus zone*. According to Ekström (1937 p. 47) *Phyllograptus nobilis* is significant of the lower subzone of the *bifidus* zone. A possible *Ogygiocaris*-fragment is recorded at 2.85 m.

At about 9 m the following occur: *Didymograptus geminus, D. speciosus* ? *Pterograptus elegans, Climacograptus angustatus, C.* sp., and *Amplexograptus* aff. *maxwelli*. The latter species also found at 10—11 m. These graptolites signify the *Didymograptus geminus* zone (Great Britain) or *Pterograptus elegans* zone (Sweden).

Another locality (Sp), not far from the Eternite factory, has in addition to the last mentioned fauna (*Pterograptus elegans* not present): *Didymograptus murchisoni* (also the Swedish form), *Phyllograptus* cf. *glossograptoides* and *P.* sp.

From about 18—23 m sandy beds occur, partly developed as thick lenses of arenaceous limestone. In the shale between are found *Ogygiocaris* sp. (Sp.).

The graptolite faunas of the Upper Didymograptus Shale of Røyken (reckoned as belonging to the Asker area of the Oslo—Asker District) show the presence of both the *Didymograptus bifidus* zone, 4a α_1, and the *Didymograptus geminus* zone, 4a α_2. The *bifidus* zone has a thickness of less than 9 m. The upper boundary of the *geminus* zone has not been determined, but the thickness of this zone might amount to about 40 m, giving a total of about 49. At Engerodden, Asker the lenses of the *geminus* zone contain some fossils (Sp.) among them a *Trinucleus* related to both *T. hibernicus* and *T. foveolatus.*

In Oslo graptolite faunas are known from many localities, but continuous sections are unknown. At Huk, Bygdøy, Hadding (1913, p. 84) and Kiær found several different graptolite faunas, but no zonal distribution was ascertained. More recent studies (Sp.) of the classical section of Huk have revealed, 0.5 m above, the basal beds of the exposed section (11.5 m above the 3c), a fauna of the *geminus*- (or *elegans*-) zone: *Didymograptus stabilis, Amplexograptus* aff. *maxwelli, Glyptograptus propinquus* and *G. teretiusculus.* 1 m. higher up: *Didymograptus nicholsoni*?, *D.* sp., *Glyptograptus propinquus, G. teretiusculus, Amplexograptus* aff. *maxwelli* and *Climacograptus* aff. *angustatus,* suggesting the same zone (Sp.).

In the City of Oslo the *geminus* (= *elegans*) zone is recorded from Stensberg gt. and Nordal Bruns gt. (*Pterograptus elegans*).

In Vestre Gravlund, Oslo, a fauna of *Climacograptus scharenbergi, Glyptograptus dentatus* (or early *teretiusculus*), *Climacograptus* aff. *transiens*? and *Didymograptus* sp., suggests the *geminus*-zone or somewhat lower.

The Ogygiocaris Shale, 4a α_3. The boundary between the Upper Didymograptus Shale and the overlying Ogygiocaris beds is not clearly defined. It is suggested by the replacement of the round yellow limestone lenses with more flat lenses showing light-grey weathering. These lenses of dark, fine-grained limestone contain the typical *Ogygiocaris*-fauna.

At Huk the *Ogygiocaris* beds appear about 32 m above the Endoceras Limestone (3c γ). 6.5 m higher up in the section a continuous sandy layer announces the overlying *Trinucleus bronni* zone (4a α_4). The thickness of the Ogygiocaris Shale is thus only 6.5 m. It should be noted, however, that *Ogygiocaris dilatata* is found occasionally, but not commonly, both below and above the zone which here is regarded as the typical Ogygia Shale of the district.

At Asker the typical *Ogygiocaris* beds seem to have a more pronounced thickness of 10—15 m, but this might be due to an earlier appearance of the fossiliferous lenses with *Ogygiocaris* (the lower lenses are larger than those of Huk).

Fossils are abundant and well-preserved in the fine-grained limestone of the lenses. Characteristic of the fauna are:

Ogygiocaris dilatata sarsi, *Nileus armadillo*, *Pseudomegalaspis patagiata*, *Trinucleus foveolatus*, *Telephus bicuspis*, *Ampyx mammilatus*, *Obolus* sp., *Lituites lituus*.

In the city of Oslo, the *Ogygiocaris*-fauna has been found preserved in shale together with graptolites at Tørtberg and Vulkan's Tomt. Among the graptolites are *Janograptus laxatus* and *Glossograptus hincksi*, the latter characteristic of the *Glyptograptus teretiusculus*-zone of Great Britain or the equivalent *Glossograptus hincksi*-zone of Sweden, the zone above the *geminus*-zone.

Near to the Eternite factory at Slemmestad a fauna containing: *Ogygiocaris dilatata sarsi* (large specimen), *Robergia microphthalma*, *Trinucleus* aff. *foveolatus-bronni*, *Glyptograptus teretiusculus*, *Amplexograptus* aff. *arctus* and *Didymograptus* (*Janograptus*?) sp., occurs higher up in the shale, about 65 m above 3c γ and about 5 m below 4a β (Sp.). The fauna ,which probably still belongs to the *teretiusculus*-zone (Bulman), seems to represent a transition between the *Ogygiocaris*- (4a α_3) and *bronni* (4a α_4) beds.

Old collections from Huk, Bygdøy, contain *Amplexograptus* cf. *perexcavatus* suggesting, according to Bulman, the zone of *Diplograptus linnarssoni*, which in Sweden succeeds the *hincksi*-zone below the *putillus*-zone.

The graptolites of the *Ogygiocaris*-beds in the Oslo Region suggest that the beds, or at least parts of them, may be correlated with the *teretiusculus*- (or *hincksi*-) zone, or parts of it.

The Trinucleus bronni-zone (*4a* α_4). As mentioned by Brøgger (1887 p. 17) the upper part of the Ogygiocaris beds has layers of arenaceous limestone. These shales with arenaceous beds and apparently a distinct fauna, seem to form a separate zone (Størmer 1930 p. 80).

As might be expected, the arenaceous beds vary considerably from place to place within the district. Since Huk has been regarded as the classical section this may be chosen as the type section.

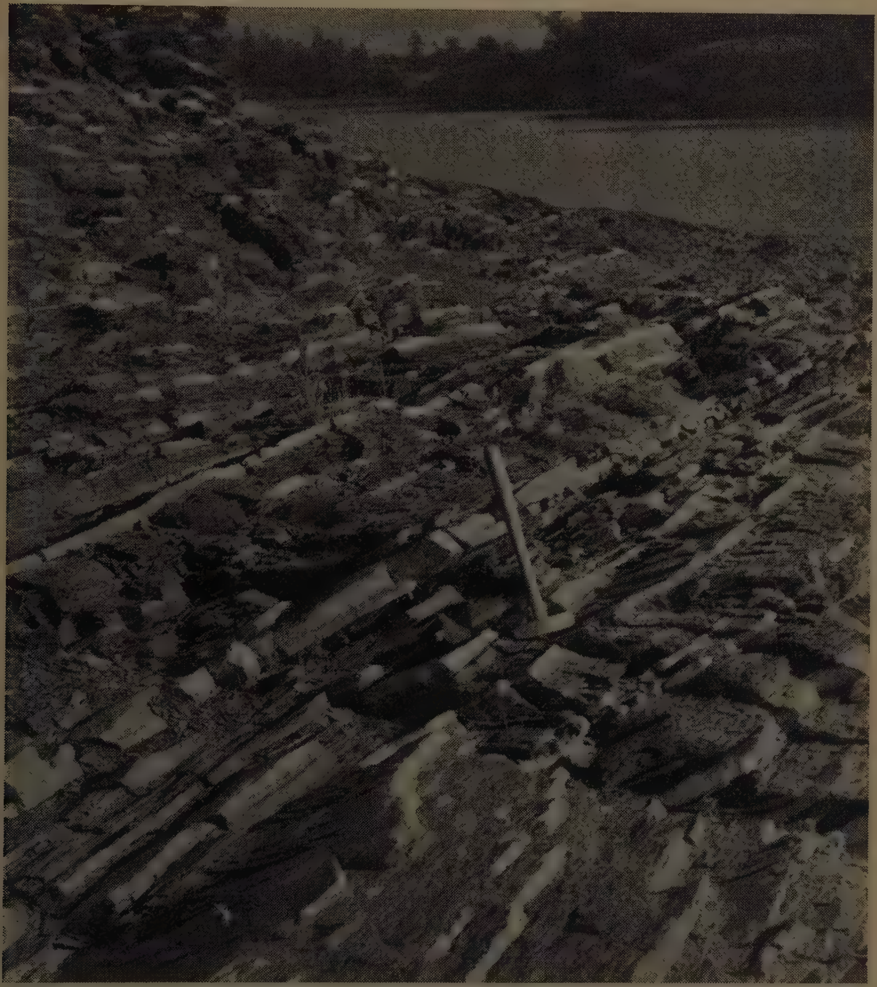


Fig. 2. Arenaceous beds of the Trinucleus bronni zone (4a α_4) on Killingskjær W of Bygdøy, near Oslo. Aut. phot.

The Ogygiocaris Shale with the flat lenses, is interrupted upwards by more or less continuous layers of calcareous sandstone. A major arenaceous band, which may be regarded as the base of the *bronni*-zone, occurs at a level of 6.5 m above the base of the *Ogygiocaris* beds (Sp.). Upwards, dark and lighter shale alternates with arenaceous and calcareous bands and lenses. Thin, 1 cm or less, laminæ of arenaceous shale (?) occur. The arenaceous bands have a thickness of 5—10 cm.

The structure demonstrated in a cross section of the layers is of particular interest. As shown in fig. 3 a distinct current bedding showing what is "up and down" in the layers, is present, especially in the lower part. In addition to this ordinary current bedding, a distinct small-scale folding is found particularly in the median and upper parts of the beds. These minor folds suggest that shortly after their deposition, the sandy beds were subject to slumping, possibly through subaquatic slides. The slumping seems to have been from W to E.

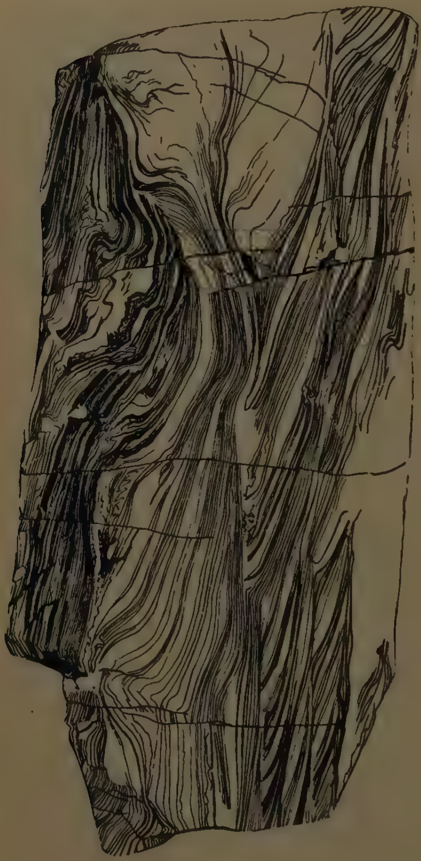


Fig. 3. Slumping arenaceous beds of the Trinucleus bronni zone (4a α_4) on Killingen by Oslo. In the lower part (to the right) of the about 10 cm thick band a normal cross-bedding is demonstrated. In the upper part, on the other hand, the beds are strongly crumbled. The drawing is based on the specimen shown on pl. 3. Length of specimen = 23 cm.

The repeated alternation of arenaceous limestone bands and shale suggests special conditions of sedimentation. We don't known, however, the amount of sand in the shale. Future detailed petrological and regional studies within one district might elucidate these problems.

The uppermost part (about 4 m) of the 25 m of shale with the arenaceous layers, has prevailing limestone bands alternating with shale. These beds seem to grade upwards into the nodular limestone of the Ampyx Limestone (4a β).

At Huk the section is somewhat disturbed by a minor overthrust of the Ampyx Limestone.

On Killingen W. of Bygdøy, the arenaceous beds, succeeding shale with smaller limestone nodules of the Ogygiocaris shale, are very characteristic, but the thickness of the zone is only about 12 m.

A similar development is found at Engerodden, Asker, where the zone of arenaceous beds and shale have a thickness of about 12 m. A little further S, however, the corresponding beds near the Eternite factory and at Djuptrekodden seem to be developed as 2.5—7 m shale with limestone nodules and bands, some of them slightly arenaceous (Sp.).

Also at Tøyen in the city of Oslo the typical arenaceous bands seem to be absent (Sp.).

Fossils are preserved both in the arenaceous beds, the shale and the limestone beds. The guide fossil is *Trinucleus bronni* (= *T. coscinorhinus*), common in the arenaceous band. Here are found a few small specimens of *Ogygiocaris dilatata sarsi*, and a small asaphid. The age of the *bronni* zone is indicated by the find in the shale between arenaceous beds at Frogner Plass, Oslo (Hm) of *Dicranograptus irregularis* characteristic of the *putillus* zone, the graptolite zone above the *hincksi* or *teretiusculus* zone.

At Slemmestad where the arenaceous beds are practically absent, a fauna evidently 1 m below the Ampyx Limestone contains a *Trinucleus* allied to both *T. foveolatus* and *T. bronni*, a form apparently characteristic also of the transition beds (*Robergia* beds) mentioned above (Sp.). This suggests that true *bronni* beds are lacking at Slemmestad, S. of Bjerkås.

The Ampyx Limestone (*4a β*). Petrologically this zone is characterized by the prevailing limestone nodules and bands. Shale is present between the limestone layers, but plays a minor part. At Huk, Bygdøy, the section is interrupted by certain thrust planes, one at the bottom as mentioned above. On Killingen near Bygdøy the apparent gradual transition from the *bronni* zone upwards into the Ampyx Limestone might be studied. The shale between the limestone bands decreases in thickness and the sediment changes into a nodular limestone. The limestone in the nodules is lighter or darker bluish-grey weathering light-grey. Occasionally separate patches, or rather clusters of barytes with a diameter of 10—15 cm, occur in the shale. At the top the Ampyx Limestone grades into the overlying Lower Chasmops Shale, the transition taking place with an increase of shale between the limestone layers. The transition might be studied at Huk, Bygdøy and i.a. at the S-point of Gåsøya.

The thickness of the Ampyx Limestone at Huk, Bygdøy is 47 m according to Brøgger. The same author mentions about 50 m at Asker, but this figure seems rather hypothetical since continuous sections are unknown.

In general the Ampyx Limestone is not rich in fossils. Brøgger (1887 p. 17) possibly included parts of the *bronni*-zone in the limestone. He mentions from the lower part among others *Ogygiocaris dilatata* and *Trinucleus bronni*? (*T. coscinorhinus* of Brøgger). From higher beds, in the typical nodular limestones, he records asaphids and raphiophorids as well as "*Trinucleus coscinorhinus*". The latter may have been confused with *T. hibernicus bröggeri* which was then unknown. *Nileus armadillo* and the *Ampyx* sp. are said to continue up to the very top of the Ampyx limestone. *Ampyx* species and *Echinosphaerites aurantium* are mentioned as characteristic fossils by Brøgger (l.c.).

At Huk, Bygdøy, *Trinucleus hibernicus bröggeri* occurs in the lowest 1—2 m of the Ampyx Limestone. *Reedolithus carinatus* is very characteristic, being found from the base to the top (Sandvika) of the Limestone. On Killingen near Bygdøy the species occurs 20 m above the base together with *Nileus armadillo*, *Cybele* sp., *Sowerbylla* and *Ullerella ulli*. The latter form also seems to be a guide fossil of the zone.

Ampyx species, i.a. large specimens of *A. costatus*, may be rare (Huk), or occur fairly abundantly (Sandvika Hz.), Mediumsized asaphids (not determined) are common.

At the very top of the limestone *Echinosphaerites aurantium* appears. As shown at Gåsøy it is a typical transitional fossil occurring at the top of the Ampyx Limestone and at the base of the Lower Chasmops Shale in this locality.

A small *Chasmops* sp. occurring in nodular limestone beds with *Nileus armadillo* at Bygdøy, also suggests a transitional fauna. Another transitional fauna with *Reedolithus carinatus*, *Chasmops conicophthalma*, *Ullerella holtedahli*, and numerous dalmanellids, is found in the eastern part of the Oslo District (Sp.).

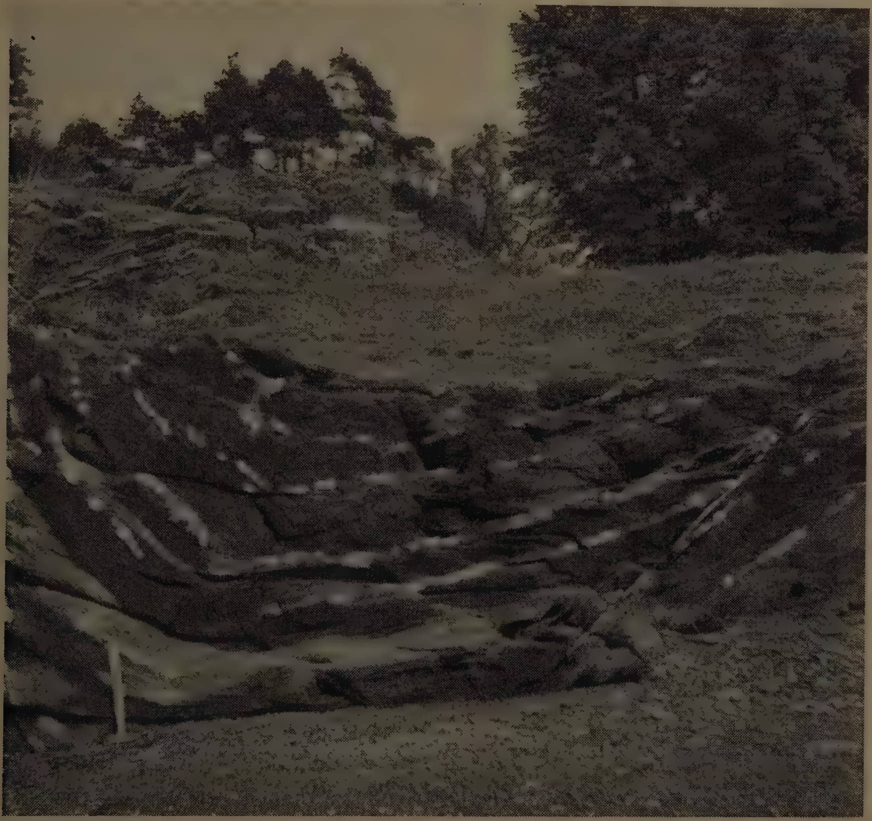


Fig. 4. Shale with layers of limestone lenses. Lower Chasmops Shale (4b α). Syncline with thrust-plane to the right. Aut. phot.

No determinable graptolites are known from the Ampyx Limestone of the Oslo—Asker district. Since the Lower Chasmops Shale belongs to the *Diplograptus molestus*-zone, it is reasonable to assume, however, that the zone corresponds to the *Nemagraptus gracilis* zone succeeding the *putilus*-zone.

The Lower Chasmops Shale (*4b α*). Brøgger (1878) describes the shale as black to greyish-black, weathering with grey colour. The lowest part of the shale has layers of limestone nodules with a thickness of 2—8 cm and a vertical distance between them of 30—40 cm. At the top of the zone about a dozen continuous limestone beds occur about 10—15 cm thick and with a vertical distance between each bed of 10—30 cm. In Asker the uppermost 10 m has layers of nodules or occasionally continuous thin layers of limestone with intervals of about 0.5 m (Arnestadtangen Sp.).

About 10 m above the base of shale, a couple of greenish layers, a few cm in thickness, are found in various localities (Grefsen, Steilene, Gåsøya) and may possibly represent altered beds of bentonite (Sp.). On account of considerable prismatic jointing the shale weathers easily.

The thickness of the zone is difficult to establish. According to Brøgger it amounts to about 40 m.

The fossils may be fairly abundant in certain localities such as at Slependen, Asker (Hz). In Oslo at Fredriks gt. beds of the Lower Chasmops Shale have exposed crinoid stems of about 140 cm in length!

Characteristic of the zone are:

Chasmops conicophthalma, *Ch.* aff. *odini*, "*Asaphus*" sp. div., *Cybele* sp., *Sowerbyella* cf. *quinquecostata*, *Christiania* cf. *tenuicincta* (Asker), *Clitambonites* cf. *schmidti*, "*Orthis*" sp. (large form), *Diplotrypa* sp., *Pseudohornera* sp., *Caryocystis* sp.

In Asker *Caryocystis* and *Pseudohornera* are characteristic of the lower part of the section, while *Sowerbyella*, *Christiania* and *Clitambonites* seem more significant of the upper part (Sp.). *Echinospaerites* occurs at the base in the transitional layers to 4a *β*.

At Slependen, Asker, some graptolites have been found and determined by Bulman as : *Climacograptus scharenbergi*, *Diplograptus molestus* (type of Hadding, not of Thorslund), *Climacograptus* sp., *Amplexograptus* aff. *arctus*. The assemblage according to Bulman indicates the *Diplograptus molestus*- or *Amplexgraptus rugosus*-zone.

The Lower Chasmops Limestone (*4b β*). In Oslo the limestone, according to Brøgger (1887), consists of densely packed limestone nodules occurring in layers about 3—4 cm thick, separated by 1—3 cm of shale. At the top of the section we find a more pronounced division into beds of limestone, about 10 cm thick, and bands of shale, up to 60 cm between the two uppermost limestone beds. The thickness of the zone is about 12 m.

At Steilene (fig. 5 b) and at Blakstad brygge, Asker the thickness amounts to 16—17 m. In the lower 3,5 m an alternation of nodular limestone, more compact limestone beds and layers of shale (up to 25 m), is found. The rest of the section consists of nodular limestone, except the uppermost part which has three compact limestone beds with 20 cm shale in between them (Sp.).

Characteristic fossils are: *Kjerulfina kjerulfi*, *K. bröggeri*, *Chasmops* sp., *Asaphus ludibundus*, *Illaenus* sp., *Trocholithes* sp., *Diplotrypa* sp., *Rhinidictya* sp. and a diploporite cystoid.

The Upper Chasmops Shale (*4b γ*). In Oslo the Lower Chasmops Shale changes into a black shale with ellipsoid lenses of fine-grained dark bluish limestone. In the lower part large lenses are scattered measuring up to 100 cm × 30 cm. In the upper part the lenses are smaller forming more continuous layers. The upper boundary of the shale is preliminarily drawn at a pyrite layer below the first more typical limestone bed (Sp.). The thickness of the Upper Chasmops Shale at Nakholmen, Oslo is 13—14 m.

A considerable variation in the thickness of the shale is characteristic of the Oslo—Asker district. At Steilene (fig. 5a, b) the thickness is 22 m and at Asker not less than 35—40 m (Sp.). At Asker the shale is greyer with limestone bands, except the uppermost 5—6 m which are developed as black shale with scattered blue lenses.

The fossils are very scarce in Oslo and Steilene, but fairly common at Asker. *Cryptolithus discors* seems to be characteristic of the zone.

The following species occur at Asker: *Cryptolithus discors*, *Kiærina* sp., *Sowerbyella* sp., *Graptodictya* sp., *Diplotrypa* sp., *Chasmatopora* sp., *Chasmops extensa*, *Nicolella* cf. *actoniae*, and *Leptelloidea* sp.; in the lower part *Pterygometopus* sp. and *Calymene* sp.

Upper Chasmops Limestone (*4b δ*). This is perhaps the most conspicuous zone of the Middle Ordovician because of its petrological characteristics and relative abundance of fossils in certain layers.

The parallel beds of limestone alternating with 20—40 cm of black shale are characteristic of the zone. In the type section of Nakholmen, near Oslo, the lower boundary of the zone is reckoned from where layers of limestone lenses (4 b γ) change into continuous beds. As mentioned above, a distinct bed of pyrite forms a natural base. In the lower part of the zone the bands of shale have a thickness of 80 cm, and occasionally carry a few lenses. The thickness of the

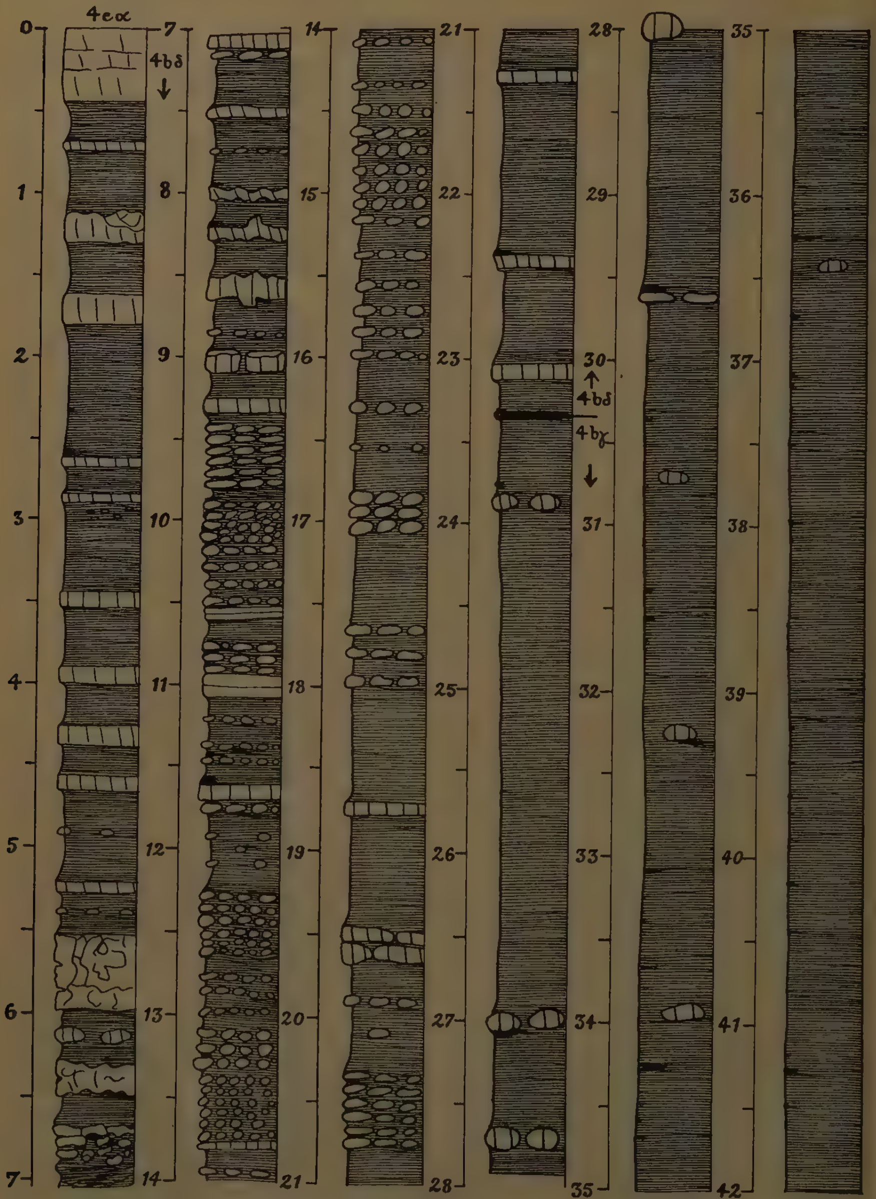
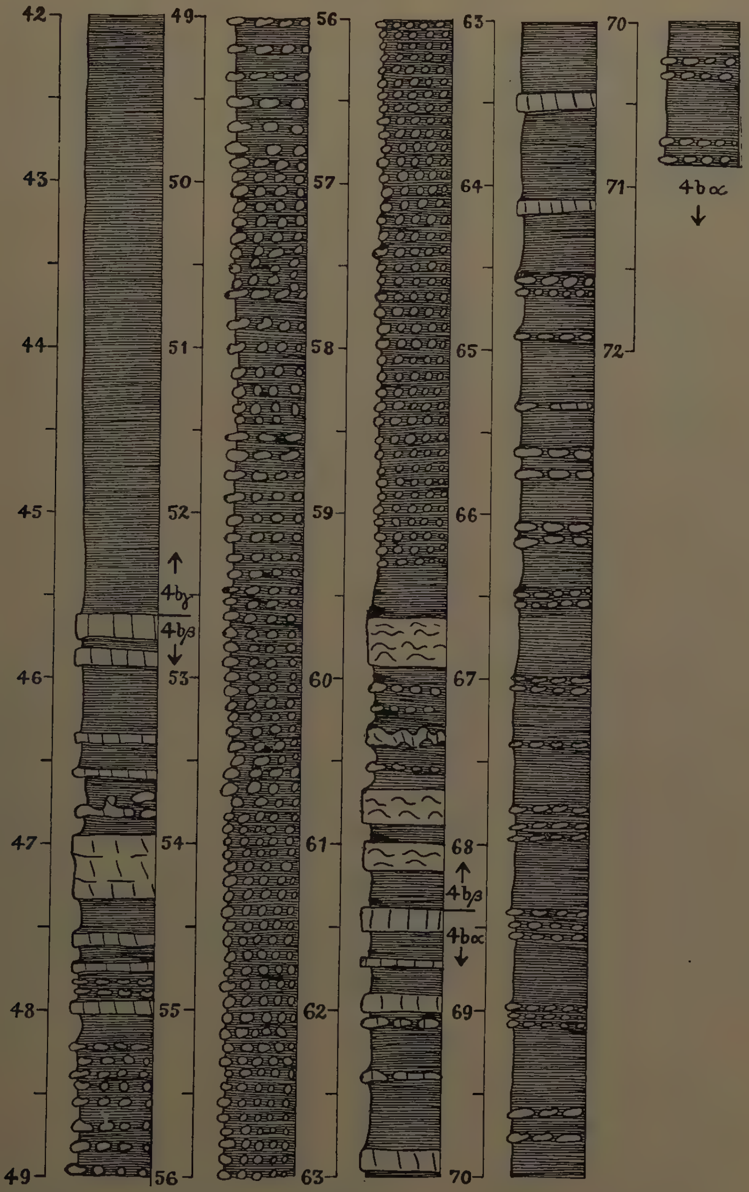


Fig. 5a, b. Detailed section through the Chasmops Beds (4b α—δ) of Steilene E. of Slemmestad. Section measured by Spjeldnæs.


4bγ
4bβ
4bβ
4bα
4bα

shale bands decreases upwards, the distance between the limestone bands decreasing to about 10 cm. Sometimes several limestone beds seem to fuse together. The uppermost limestone band lies about 15 m above the base. This thick limestone band is succeeded by black shale continuing upwards through the Lower Tretaspis Shale (4c *α*). The limestone band might form a natural upper boundary of the limestone, the fossils, on the other hand, indicate a higher boundary of the zone. Above the limestone band there is 1.20 m of black shale with a few larger lenses of dark limestone. At 1.20 m, 16.20 m above the base of 4b *δ*, a layer of phosphatic nodules indicates the real upper boundary of the Upper Chasmops Limestone at Oslo.

On Borøya, Asker, the zone has a thicknes of 23 m. Three different parts of the zone might be distinguished. The lower 15 m is developed as a nodular limestone. The middle 5—6 m has the characteristic parallel beds of limestone alternating with shale. The uppermost 2—2,5 m consist chiefly of more irregular limestone beds with less shale, the basal limestone beds resembling somewhat a reef-limestone. The absence of the lower nodular limestone in the Oslo section suggests either that these beds were not deposited at Oslo (hiatus) or that they are equivalent to the limestone beds and shale of these localities. Both the lithology and the fossil fauna suggest that the upper limestone beds in Asker represent higher (younger) strata than the highest limestone beds in Oslo. The higher beds in Asker probably correspond to both the uppermost black shale with large lenses at Oslo and to some parts of the hiatus indicated by the phosphatic layer.

The fossils are chiefly confined to the upper part of the zone. The following may be characteristic forms:

Chasmops extensa, *Tretaspis ceriodes*, *T. c. angelini*, *Illaenus glaber*, *Lonchodomas* sp., *Calymene* sp., *Stygina minor* Skjeseth (1953b), *Ptychoglyptus* (=*Rafinesquina*) aff. *münsteri*, *Hedströmina* (=*Leptaena*) sp., *Diplotrypa* sp., *Escharopora subrecta* and *Echinosphaerites* sp. (large specimens).

The characteristic *Haplosphaeronis kiæri* has been found in the Upper Chasmops Limestone of Gåsøy and Bjerkøy.

Concerning the vertical appearance of the fossil species, *Tretaspis ceriodes* is confined to the uppermost part. In Oslo only the subspecies *T.c. angelini* seems to be present.

Exposures of the Upper Chasmops Limestone are also found in the most eastern part of the Oslo—Asker district. NE of Svangstrand

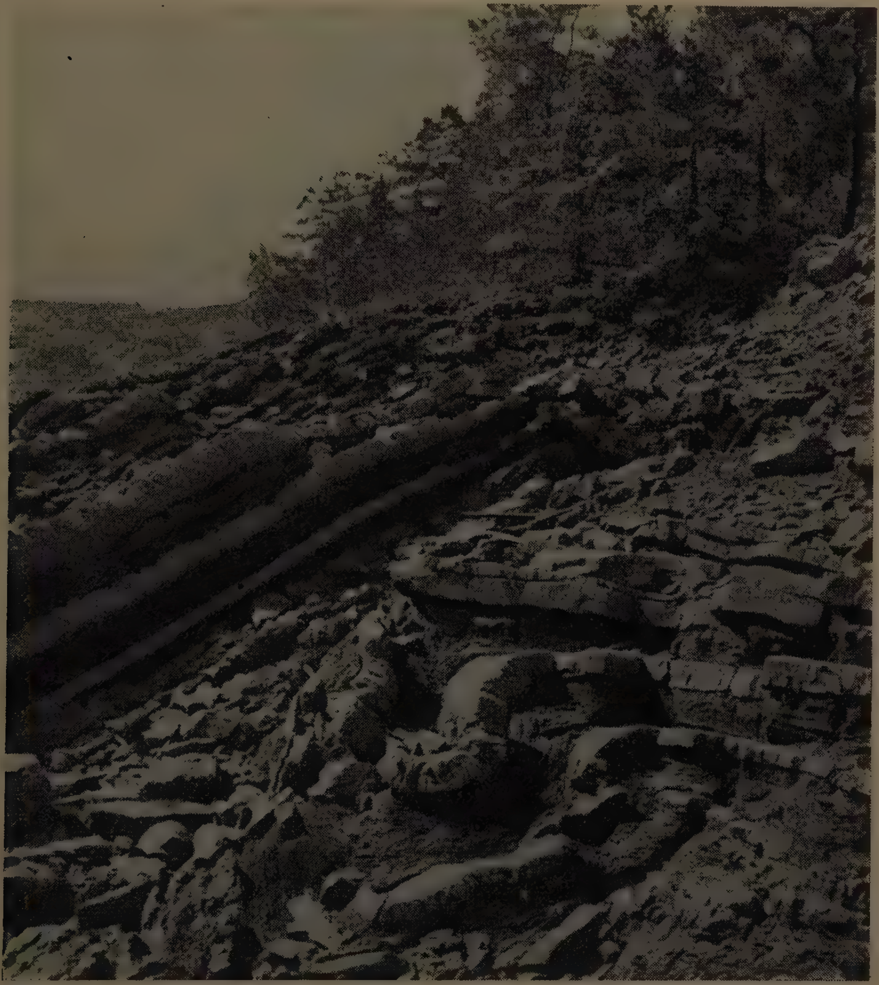


Fig. 6. Alternating shale and limestone bands of the upper Chasmops Limestone (4b δ) on Bjerkøy, Asker. The beds are densely folded inside an anticline. Jøssang phot.

at the Holsfjord, Parmann and Kiær found *Chasmops extensa, Tretaspis ceriodes,* a large *Echinosphaerites* and several other species, suggesting a development similar to that of Asker and Ringerike.

2. THE HOLMESTRAND DISTRICT.

The Middle Ordovician occurs along the coast SE of Rødtangen at the outlet of the Drammensfjord. The beds, which are folded and strongly metamorphosed, have not been studied in detail.

3. THE LANGESUND—GJERPEN DISTRICT.

Sediments of the Middle Ordovician are found all the way from the Langesund peninsula in SSE to the northern part of Gjerpen to NNW. The sediments are not folded, only tilted eastwards (about 10—30°) and intersected by numerous Permian faults partly causing a repetition of the section. Towards the Precambrian basement to the W, the Cambro-Silurian formations form a distinct escarpment or "glint".

Lying near the large intrusive bodies of the Permian larvikite, the Middle Ordovician is considerably metamorphosed. Near the border of the syenite the shales are altered into hornfels and the fossils more or less destroyed both in the shale and the limestone. Only at Herøya, the most western locality are the sediments unmetamorphosed. Here the Middle Ordovician has been studied in a core from a boring carried out by the firm "Norsk Hydro". Good sections are found along the coast W of Langesund and along the Frierfjord where the fossils are rather well-preserved.

As mentioned in the historical account, the first stratigraphical survey of the district was carried out by Forbes and Dahll. Later on Brøgger (1884) made a detailed study on the Middle Ordovician section which he divided into the stage 4a—e, a division not adopted, however, in his later paper on the Oslo section (1887).

In more recent times fossil collecting and stratigraphical studies have been carried out by Kiær, Strand, Størmer, Henningsmoen and others.

The basal transition beds (*3c* γ). At Molleklev W of Langesund (St., Hg.) the uppermost bed of the Orthoceras Limestone contains as mentioned by Brøgger (1884 p. 259) numerous specimens of asaphids: *Megalaspis grandis*, *M. gigas*, *Asaphus striatus* and *Niobe* cf. *frontalis*.

The fauna suggests a transition from the *grandis* to the *gigas* beds at the top of the Endoceras Limestone 3c γ.

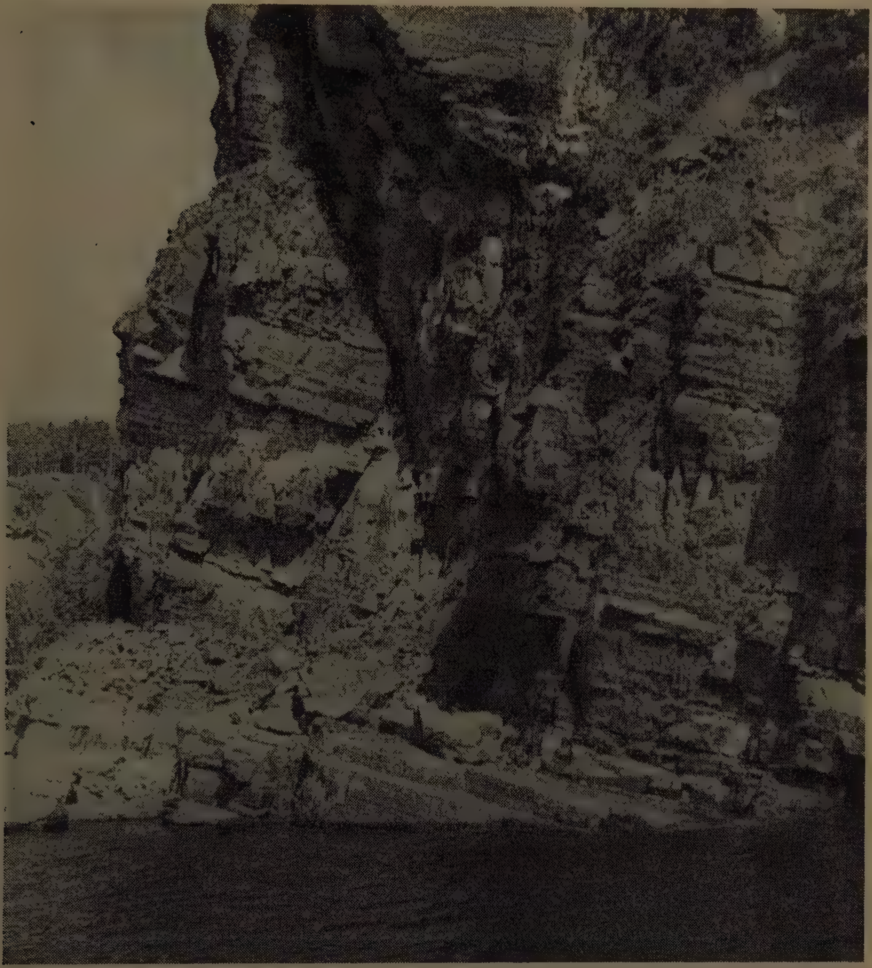


Fig. 7. The escarpment near Rognstrand W. of Langesund. The Endoceras Limestone (3c γ) at the base is succeeded by metamorphic black hale of the Ogygiocaria Series (4a α).

The limestone changes abruptly into 20 cm of black shale with *Megalaspis grandis*? (smaller form resembling the form at Slemmestad, Asker) and *Ogygiocaris* sp.

The Upper Didymograptus Shale (*4a* $\alpha_{1\text{-}2}$). At Molleklev (St,Hm) a succeeding bed with phosphate nodules apparently indicates the base of this shale. The characteristic black shale weathering to a brown colour on account of the pyrite content, is easily distinguishable even from a longer distance. The shale has several continuous layers of limestone some of which are rather thick (25 cm) and apparently arenaceous. Scattered limestone lenses occur in the upper part.

At 16,45 m above the phosphatic layer a new phosphatic bed appears.

Near the base of the Upper Didymograptus Shale, graptolites, mostly fragments, are rather common. Certain specimens from strata 37—39 cm above the basal phosphatic layer, have been determined by Bulman as: *Phyllograptus nobilis* and *Amplexograptus* aff. *maxwelli*, the former characteristic of the lower part of the *Didymograptus bifidus* zone (4a α_1).

Both Dahll (1857 p. 117) and Brøgger (1884 p. 259) also mention other graptolites, among them *Didymograptus geminus* and *D. murchisoni* indicating also the presence of the *geminus*-zone (4a α_2). The boundary between the *bifidus* and *geminus* zone as well as between the *geminus* and *Ogygiocaris* zone is not demonstrated in the section.

The Ogygiocaris zone (*4a* α_3). As already mentioned a second phosphatic layer occurs 16,45 m above the first (lowest) one situated 20 cm above 3c γ. This upper level is marked by a terrace in the section and at the same time the brownish weathering of the shale disappears and limestone lenses become more and more common upwards through the section. Petrologically, an upper boundary of this shale with limestone lenses and beds is not indicated. A closer study of the fossils, however, might give some evidence.

At 2 m above the upper level (17,69 m above the basal phosphatic layer), small trinucleids appear, and at 3 m *Ogygiocaris dilatata* and *Nileus armadillo*. *O. dilatata*, which occurs at least up to 9 m above the base (at 24.69 m), is not the form occurring at Oslo (*O.d.sarsi*), but evidently the main species originally described from the Langesund—Gjerpen district by Brünnich (1781). The other characteristic members of the Oslo-fauna such as *Trinucleus foveolatus*, *Pseudomegalaspis patagiata* and *Ampyx mammilatus*, are also missing.

7 m (22.69 m) up *Reedolithus carinatus*, the guide fossil of the Ampyx Limestone (4a β) appears. *Trinucleus* cf. *hibernicus bröggeri* occurs from 8—9 m and upwards.

The Trinucleus bronni zone ($4a\ \alpha_4$). This zone seems to be absent in the section since the guide fossil has not been found. Because of the appearance of *Reedolithus carinatus* one might be inclined to draw a lower boundary of the Ampyx Limestone at the 7 m level where this species first occurs. This would, however imply that *Ogygiocaris* continues upwards into the Ampyx Limestone and apparently that the *bronni*-zone is missing, or has its equivalent in the *Ogygiocaris* beds below the *Reedolithus* layers.

The Ampyx Limestone ($4a\ \beta$). The thick zone is well exposed along the shores of the Frierfjord and at the coast SW of Langesund.

The limestone lenses or more or less continuous limestone beds of the *Ogygiocaris* zone, become more and more frequent, the sediment changes into a shale and limestone and gradually into a nodular bedded limestone with little shale in between. The nodular limestone appears about 24 m above the Orthoceras limestone. Petrologically this Ampyx Limestone has no distinct upper boundary. The line has to be based on the fossil faunas only.

The fossil faunas do not give clear evidence as to where to draw the lower boundary of the Ampyx Limestone. As mentioned above, the characteristic *Reedolithus carinatus* and *Trinucleus* cf. *hibernicus bröggeri* occur slightly below beds with *Ogygiocaris dilatata* (forma typica). If we draw the boundary below the level with the first appearance of *Reedolithus* and *Trinucleus*, *Ogygiocaris* will belong partly to the Ampyx Limestone. At 25.45 m over the basal phosphatic layer the last *Ogygiocaris* was found and at 26 m the first *Lonchodomas rostratus* appears. Future studies may decide where to draw the line.

The characteristic fossils of Ampyx Limestone of the district are:

Reedolithus carinatus, *Lonchodomas rostratus*, *Ampyx costatus*, small asaphids, *Pterygometopus*?, in the lower part *Trinucleus* cf. *hibernicus bröggeri*.

The *Reedolithus-Lonchodomas* fauna is very constant through the considerable thickness of nodular limestone forming the Ampyx Limestone.

The upper boundary of the Ampyx Limestone is provisionally drawn at a level 37 m in the Saltboden section along the Frierfjord. At about 37 m the *Reedolithus* fauna disappears and the pelmatozoan faunas appear. The lower part of the section is not exposed at Saltboden, but found at Skindvika (Hm). Unfortunately the exact connection of the two sections is uncertain. A general comparison suggests that about 20—30 m is missing at the base of the Saltboden section. This gives a probable thickness for the Ampyx Limestone of somewhere about 60 m.

The Echinosphaerites-Bryozoan-, and Mastopora-Coelosphaeridium zones (4b α—γ).

Because of their special development these zones have been given other names than the more or less corresponding ones of the Oslo—Asker district.

Brøgger (1884 p. 261—64) distinguished two zones, a lower one (4c) with *Chasmops conicophthalma* (50—60 m) and an upper one (4d) with *Mastopora concava* (35 m). From the general impression of the fossil faunas it seems useful, at least preliminarily, to divide the *conicophthalma* zone of Brøgger into the two zones: the Echinosphaerites zone and the Bryozoan zone.

The Echinosphaerites zone. No well-marked change in the lithology is noticable. In the lower part of the Saltboden—Skjellbukten section the beds consist of shale with limestone nodules, a little more shale than in the Ampyx Limestone below. Higher up the nodules become more frequent again and in the upper part the shale increases and the beds are like those of the lower part. At Kjærvik-tangen characteristic limestone beds occur at 6.10 and 7.36 m above the base of the zone.

Characteristic fossils are:

Echinosphaerites aurantium, *Chasmops* aff. *odini*, *Pseudasaphus* ? sp. (large form), strophomenid (thick-shelled), *Diplotrypa* sp.

As mentioned above, the lower boundary of the zone is drawn where the *Reedolithus*-fauna disappears and stems of Pelmatozoans become characteristic. 15 m up in the section *Echinosphaerites aurantium* appears and is characteristic of the following 44 m. At this level the species gradually disappears to be replaced by bryozoans and associating faunas. The upper boundary is thus not distinct. The total thickness of the zone is thus 15 + 44 = 59 m i.e. about 60 m.

The Bryozoan zone. In the Frierfjord section the sediments succeeding the Echinosphaerites beds chiefly consist of shale with layer of limestone nodules. Above the shale comes a nodular limestone belonging to the overlying zone. This petrological boundary corresponds fairly well with a change in the fossil fauna.

The bryozoan beds are fairly rich in fossils. Characteristic forms are:

Chasmatopora sp., *Cliftonia* sp., Orthids and *Leptaena* cf. *minuta*.

Many brachiopods are present and forms characteristic of the underlying zone, such as *Echinosphaerites* and *Pseudasaphus* ? sp., are also found. Since *Chasmatopora* sp. is also known from the underlying Echinosphaerites beds a segregation of a separate Bryozoan zone may perhaps be questioned.

The complete thickness of the Bryozoan zone is about 40 m.

The Mastopora—Coelosphaeridium zone. 1 m below the nodular limestone the calcareous alga *Mastopora concava* appears in the section along the Frierfjord. The nodular limestone continues upwards about 20 m and then changes into shale with limestone layers or layers of nodules. From now on the section is not exposed, corresponding to a thickness of about 15 m below the Encrinite Limestone.

This covered part is demonstrated in the section of Steinsvika (Hm). 26 m of sediment (with an interruption of a covered part corresponding to 1.5 m) are here exposed below the Encrinite Limestone. In the lower half, shale with limestone lenses prevails and in the upper half, shale with limestone layers. At 4 and 4.5 m below the typical Encrinite Limestone, bands of this characteristic coarse-grained limestone appears.

When comparing the Frierfjord and Steinsvika sections one obtains the impression that the lower 10—12 m of the latter section may correspond to the top layer of the former. Beginning with the nodular limestone 1 m above the first appearance of *Mastopora*, this would give a complete thickness of the Mastopora-Coelosphaeridium zone of 35 m.

Fossils are common, the characteristic ones being:

Mastopora concava, *Coelosphaeridium* sp., *Chasmops* cf. *bucculenta*, *Orthis* sp. (*calligramma* type), *Leptaena* sp., *Platystrophia* sp. *Christiania* sp.

Coelosphaeridium is confined to the upper 15—20 m (upper 12 m in Steinsvika, but since traces of *Coelosphaeridium* ? seem to be present in the upper part of the section of Frierfjord (St.) the appearance may be somewhat earlier). In the upper part of the Steinsvika section the Coelosphaeridium beds have "worm trails" and numerous pentagonal crinoid stems in addition to the other fossils.

The Encrinite Limestone. A characteristic compact limestone measuring about 40 m in thickness, forms the uppermost zone of the Middle Ordovician in the Langesund—Gjerpen district. Between Porsgrunn and Langesund the western escarpments of the eastwards dipping limestone, are very conspicuous.

Being rather pure (90—95 % $CaCo_3$ in the richer parts) the Encrinite Limestone is of considerable commercial value (Holtedahl 1912). Numerous smaller and some larger quarries are spread all over the district. At Kjørholt the limestone is now mined below the surface. In an extensive mine owned by Norsk Hydro the annual production exceeds 600 000 tons. The $CaCO_3$ is used in producing the Ca for the fertilizer $Ca(NO_3)_2$. Limestone from other quarries is consumed by the cement factories (Dalen—Portland) or used for other purposes.

The Encrinite Limestone is partly developed as a reef limestone (fig. 8). This naturally involves a considerable local variation of the limestone. This variation has been studied by Henningsmoen and by the present author who has assisted Norsk Hydro in surveying the different limestone occurrences, and has thus had the opportunity, especially through the core-analysis, to consider the local variation of the $CaCO_3$-content.

The lower boundary of the Encrinite Limestone is fairly sharp, but a transition is indicated by the appearance of a few bands of crinoid limestone in the uppermost part of the Mastopora-Coelophaeridium-zone.

The typical crinoid limestone occurring in the lower part of the Encrinite Limestone, is a dark, occasionally lighter, bluishgrey, coarse-grained (crystalline) limestone. The occurrence of coal blende might perhaps explain the often dark colour. Some beds weather to a brownish colour due to the FeS_2-content. Stylolites on a small scale are common and a certain cyclic sedimentation is suggested. The shallowness of the deposits is demonstrated also by the presence of ripple marks and mud cracks (Hm).

At Brevik in particular, thin (less than 1 cm) light grey, nearly white, laminæ in the limestone, might possibly represent metamorphosed bentonite (Sp.). The laminæ have been subject to small-scale folding.

As indicated above, the typical Encrinite Limestone, the coarse, crystalline, nearly pure limestone, varies considerably from section

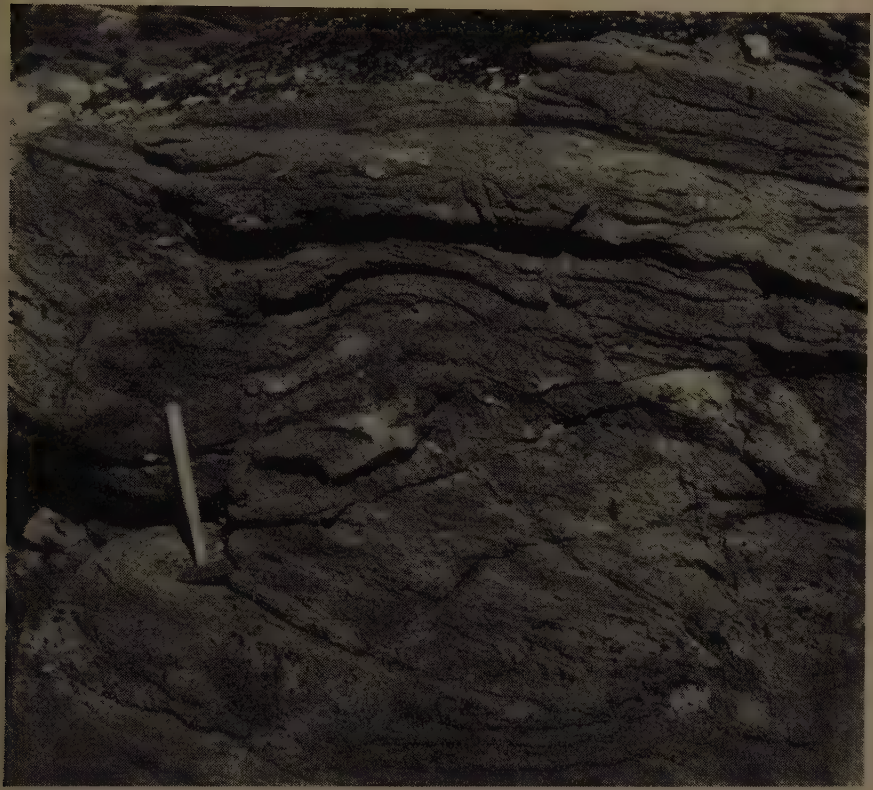


Fig. 8. The Encrinite Limestone at Steinsvika W. of Langesund. Irregular reef limestone. Aut. phot.

to section. The typical limestone is generally found at the base of the zone. At Steinsvika in the S only 1.5—3.20 m of the limestone seems to be present. Between Langesund and Stathelle and Brevik——Heistad the thickness of the zone increases considerably. Along the shore at Ås on the Frierfjord, about 8 m of reef limestone is present. The $CaCO_3$-analysis of the cores shows that the pure limestone ($> 90\ \%$ $CaCO_3$) is not restricted to the typical crinoid limestone, also the overlying, more fine-grained and less dark limestone might have a high percentage of $CaCO_3$.

Compact limestone beds continue upwards through the zone. In the upper part, however, the limestone becomes more bedded, sometimes parallel limestone beds with shale in between.

In most localities, the Encrinite Limestone has been considerably altered through contact metamorphism, and the fossils are accordingly less satisfactorily preserved. As expressed in the name of the limestone, crinoid stems are very common, locally literally building up thick beds of the limestone.

Characteristic fossils are:

Solenpora cf. *spongioides*, *Tryplasma versvikense*, *Eofletcheria irregularis*, large gastropods, *Actinomena* (= *Strophomena*) cf. *asmusi*, *Plastystrophia* sp. and *Chasmops* cf. *extensa*.

Besides the alga *Solenpora*, Kiær (1920 p. 117—18) mentions fragments of *Girvanella problematica*. In the uppermost beds of the limestone, large specimens of *Echinosphaerites* sp. are common.

4. THE SANDSVÆR—EIKER DISTRICT.

The Middle Ordovician of this district forms in many ways a continuation of the Langesund—Gjerpen development. Just as there, the sediments are generally metamorphosed and the unfolded beds dip towards the large intrusive bodies lying to the S and SE instead of to the E in Langesund—Gjerpen. In the northern part of Sandsvær—Eiker, along the Drammen Valley, the sediments lie rather flat.

Because of the metamorphism, especially of the upper part of the Middle Ordovician of this district, detailed stratigraphical work has been very limited. Brøgger (1879 p. 20) presents, based on observations by Kjerulf, a section from Krekling. In later years fossil collecting and stratigraphical-tectonic investigations have been carried out by Størmer, Strand and particularly by Heintz who is studying this district in detail.

The basal transition beds (*3c γ*). Unfortunately the transition beds are not exposed in the sections studied, the Orthoceras Limestone (3c) generally forms a covered terrace concealing the transition beds. Frequent finds of *Megalaspis gigas* at Eiker suggests that the top layers of 3c γ are present in that area. In the western part of Sandsvær, however, the Upper Didymograptus Shale seems to rest on the Asaphus Shale (3 c β), suggesting the absence of the Endoceras Limestone (3c γ) (Hz).

The Upper Didymograptus Shale (*4a $\alpha_{1\text{-}2}$*). The shale is well exposed in the river bed of the waterfall above Flata, Heistad (Hz, St, Hm, Sp). Only a small part of the section, perhaps less than 1 m?, is not exposed above the presumed Asaphus shale (3c β).

In the lower part, the black shale appears to be arenaceous and beds of arenaceous limestone are not uncommon, although the shale itself strongly prevails. Scattered layers of limestone lenses also occur

Fossils occur in the slightly metamorphic shale and partly in the limestone lenses. Already 1 m above the base, *Ogygiocaris dilatata* (forma typica?), *Asaphus* sp., and graptolite fragments occur. Asaphids and graptolite fragments are also found at about 3, 4, and 6 m, and at 12.40—12.50 a fairly rich fauna was discovered presenting: *Didymograptus bifidus*, *Ogygiocaris dilatata* (forma typica), small and broad asaphids, *Lingulella*? sp. and *Ullerella ulli*.

The graptolites show that at least 12.5 m of the shale belong to the *Didymograptus bifidus* zone (4a α_1). *Ogygiocaris dilatata* forma typica thus appears already in the *bifidus* zone.

With our present fossil material it is not possible to define the upper boundary of the *bifidus* zone. At 35.20 m, where more lenses appear in the shale, we find *Didymograptus murchisoni* (determined by Henningsmoen) indicating the presence of the zone of *Didymograptus geminus* (4a α_2).

Below this, *Ogygiocaris dilatata* forma typica is found at different levels and at 22.80 it occurs in great abundance forming the lower rich layer of *Ogygiocaris*. *Calymene* is found at 24.50 m and "*Endoceras*" from 24—31 m. Fragments of a cystid, probably *Cheirocrinus* sp. occurs in the rich *Ogygiocaris*-beds and further upwards.

The thickness of the Lower Didymograptus Shale (4a α_{1-2}) might possibly be above 35—40 m (see below).

The Ogygiocaris Shale (*4a* α_3). It is difficult to distinguish such a zone above the Upper Didymograptus Shale. The guide fossil of the district, *Ogygiocaris dilatatata* (forma typica) seems to occur already in the lower part of the *bifidus* zone and occurs in great abundance in a bed about 12.50 m below layers of the *geminus* zone. An upper rich layer of *Ogygiocaris dilatata* is found at 46.60 m which also is the last time it appears in the section.

Evidently the mixture or alternation of graptolites and trilobites (*Ogygocaris*) is dependent on the hydrographical conditions under which the faunas lived.

At 34—36 m, where *Didymograptus geminus* occurs, the shale has more limestone lenses than below. At about 39—40 m this changes again into more shale and at the same time a certain change in the fauna is noticeable. At 39 m brachiopods, bryozoans and *Ullerella* appear besides *Ogygiocaris* and a few graptolites.

The first trinucleid, *Trinucleus* aff. *hibernicus* appears in the upper rich layer of *Ogygiocaris* (46.60 m). It might possibly be compared with the species occurring in the upper part of the Ogygiocaris Shale at Slemmestad, Asker (Oslo—Asker district).

Trinucleus aff. *hibernicus* is characteristic of the beds upwards from 46,60 to at least 63 m. At 61 m the shale changes into a nodular limestone with shale, but from now on the metamorphism strongly impairs the determination of the fossils. From 68—70 m pronounced arenaceous beds with "worm trails" occur.

Judging from the development at Oslo—Asker the lower boundary of the typical Ogygiocaris Shale has to be drawn above the *geminus* zone. Provisionally it might be drawn at about 37 m. If the *Trinucleus* aff. *hibernicus* — layers should prove to be contemporaneous with those below the *bronni*-zone at Slemmestad, the upper boundary of the Ogygiocaris zone might provisionally be drawn somewhere below the arenaceous beds at about 67 m. Characteristic fossils of the true Ogygiocaris shale would then be:

Ogygiocaris dilatata (forma typica), *Trinucleus* aff. *hibernicus*, *Pseudasaphus*? sp., *Christiania* sp. The two latter forms occur in the upper part (63 m). The small globular species of *Christiania* differs from that of the Lower Chasmops Shale.

The thickness of the zone would then be about 30 m, which is rather uncertain since the upper boundary of the *geminus* zone is merely based on the absence of the characteristic graptolites above 35.60 m.

The Trinucleus bronni zone (*4a* α_4). The guide fossils have not been found. Possibly the aranaceous beds at 68—70 m belong to this zone. As mentioned below, the characteristic *Reedolithus carinatus* is found somewhat higher.

The Ampyx Limestone and Shale (*4a* β). The layers with *Trinucleus* aff. *hibernicus* and *Pseudasaphus* are also found along Muggerudkleiva, the main road up to Sagvolden. The beds just above 4 a α_3

are missing, but further up the road, shale with limestone bands contain numerous fossils. At a level corresponding to about 75—80 m in the section at Flata, *Reedolithus carinatus* occurs, indicating the Ampyx Limestone. The species is associated with: *Christiania* sp., small form, *Ampyx* sp. *Calymene* sp., *Lichas* sp., *Cheirocrinus* sp. and others.

The thickness of the zone is not known.

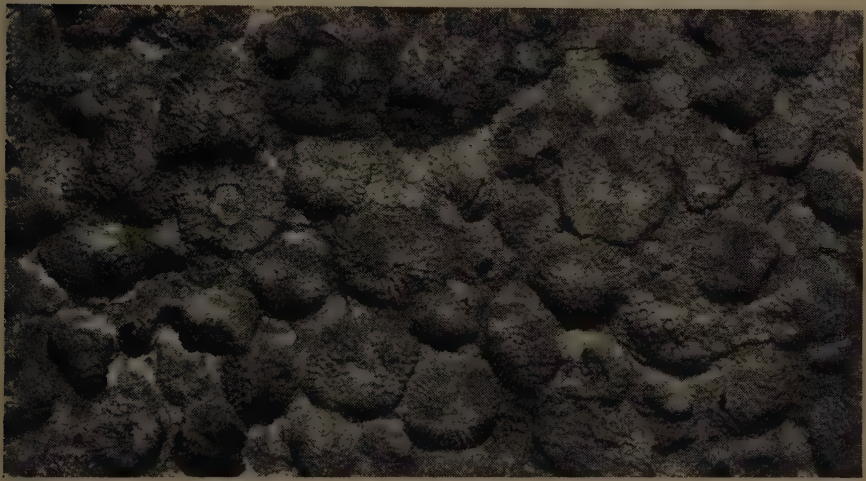


Fig. 9. The calcareous alga *Coelosphaeridium* sp. from Ravalsjøelva,Sand svær. A. Heintz coll. 1 X. B. Mauritz phot.

The Chasmops zones (*4b α-δ*). In spite of considerable metamorphism, good fossil collections have been obtained also from higher beds (Hz). In the shale with limestone lenses there occur among others: Asaphids, cephalopods, various brachiopods, *Diplotrypa* sp., *Chasmatopora* sp. and the calcareous algæ such as *Coelosphaeridium* sp. and *Mastopora* sp., the former is very common in certain layers (fig. 9). The fossils suggest a development like that of the Langesund—Gjerpen District. A highly metamorphic pure limestone at the top of the section shows the presence of the Encrinite Limestone also in this district (Hz). A future study of the section may give further details concerning the stratigraphy.

5. THE MODUM DISTRICT.

Like the two preceding ones, the Middle Ordovician of this district is located round a large intrusive body. The intrusive massive forms the nucleus in the elevated area protruding northwards between the two southern branches of the Tyrifjord. The sediments, which are largely metamorphic, form the sloping hills round the central part. In this district the Cambro-Silurian is folded such as in the Oslo—Asker district. The large Lier—Bærum syncline continues westward into the Sjåstad syncline of the Modum district.

At present little is known of the Middle Ordovician stratigraphy of the district. In the western part of the Sjåstad syncline shale with nodules contains numerous specimens of *Echinosphaerites aurantium* probably belonging to the transition beds between the Ampyx Limestone and the Lower Chasmops shale, or possibly representing a somewhat higher zone (St).

6. THE RINGERIKE DISTRICT.

This district may be divided in two parts, a southern part comprising the western parts of the low land between the two northern branches of the Tyrifjord, an area reaching N to Norderhov, and a northern part including the Middle Ordovician between Norderhov and the Randsfjord, as far as to the SE continuation of the Randsfjord fault.

The southern area forms a part of the large Ringerike syncline or synclinorium. The gently dipping beds are not metamorphosed, and the fossils well-preserved. Because of the thick and far extended glaci-fluvial deposits along the Storelva, the basal portion of the section is unfortunately but slightly exposed. In the northern area the sediments are more strongly folded and the shales are to a large extent squeezed out. Here the basal part of the Middle Ordovician is exposed, but good sections have not yet been studied in detail.

The Middle Ordovician of Ringerike is briefly dealt with by Kjerulf (1862b) in his description of a geological map. Brøgger studied the Middle Ordovician section, but both he and later on Kiær, did not publish their observations which are, however, preserved to a certain extent in their note-books. Kiær made extensive collections and in later years new collections and stratigraphical studies have been carried out by Heintz, Strand, and Størmer partly assisted by Henningsmoen.

The basal transition beds ($3c\ \gamma$). At Alm, Jevnaker, in the northern part of the district at least 1—2? m of shale with limestone beds contain a late $3c\ \gamma$ fauna. The limestone beds have a thickness of about 8 cm and the shale between about 30—40 cm. The beds contain *Megalaspis* cf. *grandis* (small species) and *M. gigas.*

The Upper Didymograptus Shale ($4a\ \alpha_{1\text{-}2}$).

The shale is evidently present, but has not yet been studied in detail. The thickness is unknown and, on account of the folding, an accurate measurement will probably also be difficult to carry out in the future.

The Ogygiocaris Shale ($4a\ \alpha_3$) *and Trinucleus bronni zone* ($4a\ \alpha_4$).

These zones are exposed along the shore at Gomnes SW of Hønefoss. No lower boundary of the shale is demonstrated and probably only the upper part of the $4a\ \alpha_3$ occurs. The lowest strata exposed consist of shale and round limestone nodules weathering to a characteristic yellow colour. Limestone flags of 2—3 cm thickness are common in the upper part. Petrologically a *bronni* zone does not seem to be separated from the Ogygiocaris shale below. The fauna collected suggests, however, both zones:

Ogygiocaris dilatata sarsi, Pseudomegalaspis patagiata, Telephus sp., *Nileus armadillo, Trinucleus bronni, Remopleurides* sp. and *Sowerbyella sericea* (St). Kiær mentions in his notes the presence of *Diplograptus* and *Dicellograptus.*

The Ampyx Limestone and Shale ($4a\ \beta$). Above the beds mentioned there is a characteristic minute conglomerate or sedimentary breccia with a thickness of 15 cm. The sediment consists of small pieces of shale, limestone and fossil fragments. This small intraformational conglomerate is succeeded by shale with limestone nodules, 5 cm shale and 4 cm of nodules. Upwards the nodules get more closely set. The further continuation of the section is not exposed. 1 m above the conglomerate *Reedolithus carinatus, Ampyx* sp. and *Asaphus* sp. are found.

At Gullerud, near Norderhov, the conglomeratic bed does not seem to be developed. Certain sandy beds and fragment beds with

Trinucleus hibernicus bröggeri, *Lonchodomas* sp., *Remopleurides* sp. and *Reedolithus carinatus* might however be the equivalent layers. In the road section studied by Kiær, shale with *Ogygiocaris dilatata* (subspecies not determined), *Telephus* sp. and graptolite fragments is succeeded, 1,5 m higher up, by shale with nodules with *Reedolithus carinatus*, *Trinucleus hibernicus bröggeri* and *Asaphus* sp. This migh possibly be due to a late appearance of *Ogygiocaris* such as in the Langesund—Gjerpen district. 7 m with *Reedolithus carinatus* is exposed, at the top of the section the species is associated with *Ullerella holtedahli*.

A more extensive section is found along the road at Kullerud. 30 m of shale with nodules and certain limestone beds. The nodules are common near the base and decrease in density upwards. Near the top limestone beds of 4—5 cm occur with 20 cm shale between. The guide fossil, *Reedolithus carinatus*, is found in the lower 10 m, the upper 20 m has practically no fossils except a few graptolite fragments. It is therefore hardly possible to distinguish the upper boundary of the zone. Probably a considerable part of the section belongs to the overlying Lower Chasmops Shale.

In a road cut at Putten, a little further N, the thickness of the 4a β seems to be at least more than 19 m.

Characteristic fossils of the Ampyx Limestone and Shale (4a β) are: *Reedolithus carinatus*, *Trinucleus hibernicus bröggeri* and *Ullerella ulli*. In addition to these are *Remopleurides* sp., and Asaphids.

The Lower Chasmops Shale (*4b* α). This important zone was studied in detail by Kiær who discovered and made extensive collections in the rich beds along the shore at Bratterud. Besides Bratterud, Kiær studied in detail the road cutting between Gomnes and Ruud, which is now overgrown. Fortunately his notes give satisfactory information about the stratigraphy.

As mentioned above, the 4a β shale with frequent lenses or nodules gradually changes into a more pronounced shale with few lenses. This grey shale represents the lower part of 4b α, but the actual boundary is difficult to ascertain.

The basal part of the zone was exposed at Gomnes—Ruud (Kiær). A shale with fairly frequent, small limestone lenses yielded: *Chasmops* cf. *conicophthalma*, *Ullerella holtedahli*, *Echinosphaerites* and *Haplosphaeronis* cf. *kiæri*, *Diplotrypa*. Slightly higher up, where the shale becomes more pronounced, *Christiania* sp. appears, the brachiopod which Kiær noticed as very characteristic of the lower part of the Chasmops Series.

Another transition fauna has been collected at Gullerud (St). In shale with limestone lenses the following occur: *Chasmops* sp. (small form), *Asaphus* sp., *Pterygometopus* sp., *Calymene* sp., *Ampyx* ? sp., *Ullerella holtedahli*, *Sowerbyella* sp., and *Christiania* sp.

A lower boundary of the Lower Chasmops Shale may provisionally be drawn where the shale and limestone lenses change into a more typical shale, and where the typical *Christiania*-fauna appears.

The lowest part of 4b α seems to be lacking in the Bratterud-section. According to new measurements (St) the section comprises about 34 m of greyish-green shale with scattered limestone lenses or layers of lenses, and a few distinct arenaceous beds (at about 13, 24.5, 28, 31, and 32.5 m). A certain tectonic interruption of the section is present, but the total thickness is hardly much different from that which is measured.

The lowermost part of the section (previously exposed) comprises 3—4 m of shale with *Christiania* cf. *tenuicincta* (round type). Above this there is 24 m of shale with limestone lenses, scattered, or appearing in layers with shale between. Specimens of *Diplotrypa* are very common. In the upper 6 m, limestone beds, some of them arenaceous, are prevailing. In this upper part, *Christiania tenuicincta* occurs in large, oblong specimens (Kiær). The upper boundary of the zone is drawn where more closely set limestone beds appear (at about 35 m). Since some of the basal part is missing at Bratterud the complete thickness of the shale probably amounts to about 35—40 m.

The fossil fauna might be characterized largely as a fairly coarse, shelly fauna with brachiopods and bryozoans as the more prevalent fossil fauna.

Characteristic fossils are: *Actinomena* (= *Strophomena*) *asmusi*, *Kjerulfina bröggeri*, *Öpikina dorsata* (="*Rafinesquina imbrex*"), *Ö. deltoidea*, *Sowerbyella* sp., *Orthis* sp., *Diplotrypa* sp., *Chasmatopora* sp., *Hemiphragma* sp., *Chasmops* aff. *extensa*, *Illaenus* cf. *glaber*.

The Lower Chasmops Limestone (*4b* β). The road section Ruud—Solheim cuts through 28 m of limestone and shale. The upper 25 m of these probably belong to 4b β. There is no sharp boundary between 4b α and 4b β. In the top layers of 4b α, limestone bands appear and become more and more abundant. Limestone beds, a few of them with a thickness of 15—20 cm, alternate with shale and more or less closely packed limestone lenses. Where thick limestone beds occur, more shale is present immediately below and above, thus giving a more constant ratio between limestone and shale through the zone. Layers of more typical nodular limestone are also present.

The complete thickness of the Lower Chasmops Limestone appears to be 25 m, the lowest 3 m of the Ruud—Solheim section probably belongs to 4b α (St).

Fossils are scarce in the section; only *Sowerbyella* and a few cystids. A richer fauna was collected by Kiær at Juvern, the old river bed of Storelven. Characteristic fossils are:

Chasmops sp., *Illaenus glaber*?, *Lonchodomas* sp., *Actinomena asmusi*, *Strophomena rigida*, lamellibranchs and *Diplotrypa*.

The Upper Chasmops Shale (*4b* γ). The limestone of 4b β is succeeded by shale often with large limestone lenses. The soft grey shale is generally not much exposed. A section from 4b β through 4b γ to 4b δ is partly exposed along the road Southwards from Ødegården. The thickness of the shale is not measured. A rough estimate would suggest somewhere between 20—30 m.

Fossils are common i.a. at Vestbråten and Juvern. Characteristic of the fauna are:

Lamellibranchs, *Chasmops* cf. *extensa*, *Kjerulfina kjerulfi*, *Öpikina deltoidea* and *Sowerbyella*.

The Upper Chasmops Limestone (*4b* $\delta_{1\text{-}2}$). No complete section through the limestone has been studied. Along the main road S. of Norderhov 12.5 m is exposed, excluding the base and the top, and at Frognøy (the most southern locality), the upper 6 m are demonstrated.

S. of Norderhov the lowest 2 m consist of nodular limestone; then there comes 6 m of mostly parallel beds of limestone alternating with shale such as in the Oslo—Asker district. The uppermost 4.5 m is developed as a more or less compact limestone. In the lower part of this limestone (8.5 m above exposed base) the following characteristic fossils appear: *Tretaspis ceriodes, Lonchodomas* sp. and *Stygina minor* Skjeseth (1953b) and in addition to these, *Calymene, Lonchodomas* sp., ''*Rafinesquina*'' sp. and *Sowerbyella*. Higher up *Echinosphaerites* occurs (large form) (St).

At Frognøy the 3.5 of compact limestone at the base might in part correspond to the uppermost part of the former section. This compact limestone, carrying numerous specimens of a large *Echinosphaerites* in the lower part, is succeeded by 2.5 m of fairly thick limestone beds alternating with less shale. In one of the basal limestone beds Kiær (1921 p. 499) discovered a rich fauna with ''*Trinucleus*'' and ''*Ampyx*''. Since he believed that the *Tretaspis* species was more closely related to the characteristic *T. seticornis* above, he regarded the limestone beds as belonging to a new zone which he called the Lower Trinucleus (= Tretaspis) limestone. The *Tretaspis*, however, proved to belong to a new species, *T. kiæri*, which suggests a closer relation to *T. ceriodes* of the 4b δ and therefore suggests a connection with the Chasmops Limestone rather than with the overlying Tretaspis series (Størmer 1930 p. 57, 1944 p. 393).

Strangely enough, a single specimen of *Tretaspis seticornis* was found about 1.3 m above the rich layer of *T. kiæri*. If one can rely on the *Tretaspis* species as being good guide fossils, which they seem to be, this means (l.c.) that the boundary between the Chasmops- and Tretaspis Series, i.e. between 4b δ and 4a α, runs in the middle of the 2.5 m of limestone beds alternating with shale (similar conditions are found in Hadeland as shown below).

Since the layers are distinguished by a special guide fossil, it seems natural to divide the Upper Chasmops Limestone of Ringerike into two subzones, a lower one with *Tretaspis ceriodes* (4b δ_1), and an upper one with *Tretaspis kiæri* (4b δ_2).

The exact thickness of Upper Chasmops Limestone is not known, but it probably amounts to about 15 m.

Characteristic fossils are:

Chasmops extensa, Tretaspis ceriodes (4b δ_1), *T. kiæri* (4b δ_2), *Lonchodomas* sp., *Stygina minor, Phillipsinella parabola* (4b δ_2), *Actinomena asmusi* and others.

The fossil faunas are very rich. Numerous species of trilobites and brachiopods are present; of interest is the occurrence of *Haplosphaeronis kiæri*.

7. THE HADELAND DISTRICT.

The Middle Ordovician sediments are chiefly confined to the E of the Randsfjord, S. of Røykenvik and N and W of the igneous areas of Nordmarka and Hurdal. A Permian fault of considerable throw, runs N-S along the Randsfjord; the southern continuation of the fault, running SE, makes a somewhat artificial boundary between the Ringerike and Hadeland districts. The eastern boundary of the Cambro-Silurian sediments is one of erosion, the Precambrian peneplane dips westwards below the Paleozoic series.

The sediments are strongly folded with a prevailing northern dip and a W—E strike. In general the folds pitch slightly westwards towards the fault. While the mostly incompetent lower beds of the Cambro-Ordovician are strongly folded with numerous fairly small and sharp folds, the incompetent and thick limestone zones at the top of the Middle Ordovician, form large, gentler folds. The present author considered the possibility of large overthrusts because of a rapid change in facies (Størmer 1943b), more recent studies, however, seem to suggest the rapid changes in facies are primary, rather than due to overthrusts.

The Hadeland district was mapped by Kjerulf (1862) and Münster (1901) and more recently by Holtedahl and Schetelig (1923). Holtedahl (l.c.) and Kiær (1926) pointed out the difference in the NW and SE development of the Ordovician of the district and later on Størmer (1945) found the change in facies to be strongly marked along a W—E line between Gran and Lunner.

In describing the Middle Ordovician of the district, one has to consider the northern and southern sections separately and try to find out, as far as possible a connection between the two developments.

In the following (N) after a placename means an occurrence N of the W—E-line corresponding largely to the boundary between the parishes Gran and Lunner. (S) means S of the mentioned line.

Recent stratigraphical work connected with mapping has been carried out by Størmer assisted by Henningsmoen, Major, Dons and Skjeseth. Holtedahl has kindly permitted me to use his previous notes.

The basal transition beds (*3c* γ). At Hovodden on the Randsfjord (N), a good section through the basal beds is exposed. The uppermost layers of the compact Endoceras Limestone (3c γ) is crowded with specimens of endoceratids. Upwards the compact limestone gradually turns into a bedded limestone, limestone beds and shale, and eventually a shale with limestone lenses. The bedded limestone forms the lower 2 m. This, and the following 6 m of shale with lenses, contain the same fossil fauna with the characteristic fossils: *Megalaspis grandis* and *Asaphus striatus*.

This subzone is succeeded by 3 m of shale with lenses containing *Megalaspis gigas*.

Above this subzone there is another 3 m of shale with lenses in which *Asaphus* (*Neoasaphus*) *bottnicus* Jaanusson 1953 was found. The specimen was kindly determined by Fil.lic. Jaanusson who mentions that the species occurs in the Crassicauda Limestone which probably corresponds to our 4a β?

The section thus indicates the presence of two upper subzones of 3c γ and an extra zone, the age of which is uncertain. As shown in Pl. 5 the development of 3c γ thus differs considerably from that in Oslo where a distinct *grandis*-zone is not noticeable.

The basal transition beds are not exposed in the southern part of the Hadeland district.

The Upper Didymograptus Shale (*4a* $\alpha_{1\text{-}2}$). On account of the strong folding, causing considerable jointing and compression of the shale, the fossils are not preserved in the shale itself and a continuous section cannot be measured. Since no well-preserved graptolites have been found, the stratigraphy of the lower part of the Ogygiocaris Series is impossible to make out. Probably the Lower Didymograptus shale is present in a more or less "normal" development, but no exact data exist. The upper beds of Hovodden might have represented a "shelly facies" of the Upper Didymograptus Shale, but the one fossil found points, however, to younger zones as mentioned above.

The Ogygiocaris Shale (*4a* α_3). The shale is well exposed at Røykenvik railway station (N) where it has been studied by Holtedahl (Holtedahl and Schetelig 1923 p. 20). He describes the shale as black to dark-grey, argillaceous, with flat limestone lenses containing *Ogygiocaris*, *Nileus* and *Obolus*. The thickness of the Ogygiocaris Shale (4a α_3) is unknown.

The fauna is the typical *Ogygiocaris*-fauna of Oslo—Asker:

Ogygiocaris dilatata sarsi, Pseudomegalaspis patagiata, Nileus armadillo a. o.

The guide fossil is also found in the Vigga Valley (S). (St).

The Cephalopod Shale (*4a α_4?*). As discussed below, at least a major part of this shale may correspond to the *Trinucleus bronni* zone (4a α_4). According to the description by Holtedahl (l.c.) the typical Ogygiocaris shale is succeeded by a few m of nodular limestone (like in the Mjøsa districts) and then by dark shale with irregular, more or less rounded lenses which in a weathered state are seen to contain numerous cephalopods and gastropods. In the Vigga Valley (S) rounded lenses also occur, but less typical apparently.

The thickness of this shale is very considerable. Holtedahl assumes a thickness of possibly 100 m for the combined 4a α_{1-3} and the Cephalopod Shale.

Neither petrologically, nor faunistically does the *Ampyx Limestone* (4a β) of the Oslo—Asker section seem to be developed at Hadeland. Parts of the arenaceous beds above the Cephalopod Shale in the Northern part of Hadeland, might correspond to parts of the Ampyx Limestone.

The Lower Chasmops Shale (*4b α?*) *of the south and the shale with arenaceous beds of the north* (*4a β—4b α?*). S. of Kraggerud, in the Vigga Valley (S), grey shale, fairly thick, comes on the top of the Cephalopod Shale. The shale has been subject to considerable prismatic jointing. Only "worm trails" and a few fossils (*Lonchodomas* sp., *Asaphus* sp) have been noticed.

At Røykenvik (N) there occurs a series of shale with limestone bands and thick beds of calcareous sandstone. The shale, which apparently has very few fossils, has not been studied in detail. Holtedahl mentions bryozoans only and assumes a possible thickness of about 40 m for the zone.

The Middle Chasmops zones (*4b β—γ*) *of the south and the Coelosphaeridium—Cyclocrinus zones of the north*, Considerable difference is found in the development of the North and South. While the latter resembles the Mjøsa sections, the former shows some connections with those of Ringerike and Oslo—Asker.

At Lunner (S) and E of the Vigga Valley (S), the Lower Chasmops shale (4b α) is succeeded by a zone of shale with distinct continuous limestone layers or of fairly large lenses of limestone. The thickness of the zone is about 10—15 m (continuous sections not studied in detail). The limestone beds may be rich in fossils. Characteristic forms are:

Chasmops cf. *extensa*, *Calymene* sp., *Ampyx* sp., *Remopleurides* sp. and *Kjerulfina bröggeri* ?

A similar fauna has been found about 40 ? m below the Sphaeronid Limestone at Nerby (N). The zone might possibly correspond to the Lower Chasmops Limestone (4b β) of Oslo—Asker.

In the section at Lunner (S) the continuation upwards is as follows: 36 m of shale with scattered lenses (not well exposed), then 3,5 m with limestone bands in the shale, then 40 m of badly exposed shale, and at the top below the Upper Chasmops Limestone (4b δ), 11 m of shale with frequent limestone lenses. This gives a total of not less than about 90 m, a thickness perhaps too great for a zone possibly corresponding to the Upper Chasmops Shale (4b γ) only.

Fossils have not been collected in the shale.

At Røykenvik (N) the thick shale with conspicuous arenaceous layers, corresponding to the Lower Chasmops Shale (4b α) and probably some older beds (4a β), continues upwards in zones resembling the *Coelosphaeridium* and *Cyclocrinus* beds of the Mjøsa districts as pointed out by Holtedahl (l.c.).

The lower part of the section along the shore south of Røykenvika, consists of 30 m of prevailing greyish-green shale with limestone lenses, particularly in the lower 10 m, and lenses particularly in the upper 10 m. Fossils are rather common, as characteristic the following may be mentioned:

Leptaena rhomboidalis, *Öpikina* sp. and *Diplotrypa*; near the top large specimens of *Diplotrypa*, *Chasmops* cf. *conicophthalma*, and *Strophomena* sp.

The upper part of the section comprises about 25 m of more calcareous deposits, the mostly continuous limestone bands prevail in comparison with the alternating shale. Arenaceous beds are common. One bed may consist of limestone at the top and a sandy bed at the base. Characteristic fossils seem to be:

Diplotrypa (small specimens), *Illaenus* sp., *Cybele* sp. and *Sowerbyella* sp.

The contact to the overlying Sphaeronid Limestone is not exposed, but the thickness given is not far too low.

In the Røykenvik section, the lower 30 m probably correspond to the *Coelosphaeridium* beds, and the upper 25 m (or a little more) to the *Cyclocrinus* beds.

At Tønnerudodden (N), further S., a series of 40 m are exposed below the Sphaeronid Limestone (Kiær 1926).

The lower 18 m of the exposed section consists of shale with less frequent limestone beds and lenses. Characteristic fossils of this "Cyclocrinus Shale", according to Kiær, are:

Diplotrypa sp. (large specimens), *Sowerbyella sericea, S. schmidti precedens, Platystrophia* sp. *Cyclocrinus* sp. (small).

Above this there is 22.5 m of "Cyclocrinus Limestone". Of this the lower 17 m consists of bedded limestone with shale, a few limestone beds being arenaceous. Large *Diplotrypa* specimens are common. The overlying 2 m are developed as a nodular limestone and the uppermost 4 m as shale, with large ellipsoid limestone lenses ("Gastropod Limestone" of Holtedahl). Besides large gastropods certain cup-corals occur determined by Hill (1953) as: *Streptelasma curvatum, S. holtedahli* and *S.* sp.

At Nerby (N) a shale with limestone lenses, about 2 m below the Sphaeronid Limestone contains numerous specimens of *Sowerbyella* sp. besides *Illaenus* sp., *Diplotrypa* sp. a.o.

The Upper Chasmops Limestone (4b δ) of the south and the Sphaeronid Limestone and Gagnum Shale of the north. The Upper Chasmops Limestone forms a characteristic zone in the southern part of Hadeland. The W—E limestone ridges are conspicuous in the area round Roa and at Lunner. Tectonically the limestone forms more or less V-shaped synclines in which the basal portion is very often narrow.

A section through the Upper Chasmops Limestone might be studied W of Lunner railway station (S). The lower 6 m consist of grey limestone beds with some shale between the layers. The next 13 m are chiefly developed as a nodular limestone. In the upper 23 m, limestone beds alternating with some shale, prevail. The general impresion of the zone is a series of compact limestone beds separated by thin layers of shale. The nodular limestone is subordinate. The alternation of limestone and shale is of considerable importance in the tectonic behaviour of the zone. Because of the lamination a differential movement of each layer of the limestone might be permitted. During the folding the Upper Chasmops Limestone therefore acted more as a pack of separate limestone beds rather than one compact limestone zone. This explains the comparatively steep folds.

In the railroad section S of Lunner station the upper part (20 m) of the limestone is exposed (Størmer 1945 p. 383). At the base of the exposed part 2 m of limestone layers and shale appear. Then 4 m of nodular limestone above which there is a compact limestone of 9 m with the following characteristic fossils: *Tretaspis ceriodes*, *Lonchodomas* sp. and large *Echinosphaerites* sp. The uppermost 5 m form an apparent gradual transition into the overlying black Tretaspis Shale (4c α). At the transition, arenaceous beds and beds with trails are present suggesting shallow conditions or a hiatus. The conditions are similar to those of Ringerike (Frognøy).

The typical bedded limestone is found close to the W—E line separating the northern and southern facies. The compact limestone beds occur i.a. at the outlet of the small pond at Korsrudbråten.

As suggested in the section at Lunner, the thickness of the Upper Chasmops Limestone in the southern part of Hadeland, amounts to about 42 m (previously assumed by me to be about 25—30 m).

Characteristic fossils are:

Chasmops extensa (not common), *Tretaspis ceriodes*, *Lonchodomas* sp., *Stygina minor* Skjeseth (1953b) *Strophomena* sp. and *Echinosphaerites* sp. (large forms).

The Sphaeronid Limestone is characteristic of the northern development N of the W—E line at the boundary Lunner—Gran. The limestone at Tønnerudodden (N) was described in detail by Kiær (1926). In this locality a tripartite division of the limestone is noticeable.

1. (Base). The Lower Sphaeronid Limestone consisting of 16—17 m of a densely packed light grey nodular limestone with *Vermiporella* sp., *Dacyporella* sp. a *Streptelasma*-form, and bryozoans.

2. The Sphaeronid Shale forms 7 m of grey-green calcareous shale with *Haplosphaeronis kiæri*, *Leptaena minuta*, *Chasmops* sp., *Tretaspis* sp., *Stygina* sp., *Sowerbyella* cf. *quinquecostata*, and *Dalmanella* sp.

3. The Upper Sphaeronid Limestone, consists of at least 25 m of light grey nodular limestone with *Haplosphaeronis kiæri*, *H. k. norvegica*, *Chasmops* sp., *Stygina* sp., *Platystrophia biforata*, *Öpikina* cf. *dorsata* (= ''*Rafinesquina imbrex*''), and *Diplotrypa* sp.

Further E, at Nerby, just N of the W—E line, a more or less continuous section through the limestone is exposed. The section comprises (Størmer 1943b and 1945 p. 387) 70 m of light grey nodular limestone. Only a few limestone beds (with little shale) interrupt the rather uniform nodular limestone. Tectonically the compact nodular limestone behaves differently from the bedded Upper Chasmops Limestone further south. The Sphaeronid Limestone forms larger, U-shaped, open synclines.

Fossils are abundant in certain layers. At 12—15 m a fauna was collected among which the following are characteristic:

Haplosphaeronis kiæri, *Chasmops extensa*, *Tretaspis ceriodes*, *Stygina minor* Skjeseth (1953b), *Ampyx? aculeatus*, *Sowerbyella* sp. a.o.

The guide fossil *Haplosphaeronis kiæri* is also found higher up in the limestone.

A short part of the section is missing above the limestone. The thickness of the Sphaeronid Limestone, which here is not divided by an intermittant shale, amounts to 70—75 m.

The Gagnum Shale overlies the Sphaeronid Limestone at Nerby—Gagnum (N). The shale is dark grey with comparatively thin layers of limestone nodules. The thickness is 20—25 m.

Characteristic fossils are: *Tretaspis ceriodes*, *Lonchodomas* sp., *Stygina minor* Skjeseth (1953b), *Illaenus parvulus*, *Remopleurides* sp., *Calyptaulax* [*Homalops*] *norvegicus*, *Platystrophia* sp. and orthids.

In the shale there has also been found *Tretaspis kiæri*. The presence of *T. ceriodes* and *T. kiæri* indicates that the shale is not identical with the Tretaspis Shale (*T. seticornis*), but corresponds to the upper part of the Upper Chasmops Limestone, a development faunistically equivalent to that of Ringerike (Størmer 1945).

8. THE FEIRING DISTRICT.

The Middle Ordovician of this district is strongly metamorphosed, fossils being but badly preserved. Vogt (1884 p. 215) has described the section W of Lake Mjøsa. Shales of ''stage 4'' occur above the

Orthoceras Limestone in many of the sections. In spite of the metamorphism measurement of thickness may be possible.

9—11. THE MJØSA DISTRICT.

These three districts are often treated as one unity, the Mjøsa District. Previous and present researches have usually comprised all three districts at the same time. In this general review it might, therefore, be useful to do the same.

Cambro—Silurian rocks form the base of the rich agricultural districts round Lake Mjøsa. Because of the cultivated fields, good exposures are scarce being chiefly confined to quarries, road- and railway cuts and outcrops along the rivers and shorelines.

The Mjøsa districts as a whole, are bordered on the W by the Precambrium by the Hundselv fault, on the N largely by the Eocambrian rocks (''sparagmites'') (as pointed out by Skjeseth the northern boundary of the Oslo Region might be drawn S of the Ringsaker district), to the E to the exposed underlying Precambrian, and to the S chiefly by the igneous rocks of the Feiring district. Major Permian faults split up the region into different tectonic units. As shown by Skjeseth (1952a) the preservation of the Cambro—Silurian is largely due to the subsidence and slight tilting of the rocks between major faults. A conspicuous horst of Precambrian rocks is maintained, forming the Solbergås between Ringsaker and Nes.

The Middle Ordovician sediments are strongly folded. Due to the closer neighbourhood of the axial belts of the Caledonian mountain range, overthrusts occur in addition to the folds. As shown by Skjeseth (l.c.) the Cambro—Silurian sediments of Ringsaker are probably allochthonous, belonging to a nappe or sheet thrust over the paratochthonous series below.

The Middle Ordovician of the Mjøsa districts was treated briefly by Hisinger (1823, 1828), who presented a drawing of *Coelosphaeridium*, and by Kjerulf (1857, 1862c). A more detailed stratigraphical study of the Mjøsa Limestone was presented by Kiær (1897) and some years later, Holtedahl (1909) gave a detailed account of the remaining part of the Middle Ordovician.

Holtedahl divides the "stage 4" into two series, a lower Asaphid Series and an upper Chasmops—Siphoné Series. The further division is as follows:

I. Asaphid Series. 1. Ogygia (= Ogygiocaris) shale, 2. Nodular limestone, 3. Shale with cephalopods and gastropods.
II. Chasmops—Siphoné Series. 1. Shale and limestone without fossils, 2. Calcareous limestone and shale with *Coelosphaeridium*, 3a. Shale with *Cyclocrinus*, *Chasmops*, *Leptaena* etc., 3b. Limestone with the same fossils.

Comprehensive fossil lists and correlation with other regions as well as remarks on the lithology, are given in Holtedahl's paper.

More recently, Skjeseth (1953a) has dealt with the Lower Ordovician of the districts and he his now carrying out a detailed study and mapping of the Middle Ordovician of the whole region.

Middle Ordovician fossils have been collected by Kjerulf, Brøgger, Kiær, Rekstad, Münster, Holtedahl, Rosendahl, Strand and H. Major.

9. THE TOTEN DISTRICT.

Like the Hadeland District the Toten District is bordered on the W by a prominent Permian fault (concealed by the Randsfjord in the former case).

In both cases, the subsided area dips gently towards the fault, this leaving the younger beds preserved in the western part only. Another Permian fault, a southern continuation of one crossing Helgøya, changes the pitching of the folds eastwards (Sk).

The Middle Ordovician is strongly folded with a W—E strike. The thick and compact Mjøsa Limestone forms characteristic synclines in the western part of the district.

The basal transition beds (*3c* γ). The development of the Orthoceras Limestone (3c) is different from that of the southern districts mentioned. At Raufoss the limestone consists of 14 m of bedded compact limestone with a characteristic reticulate surface formed by fissures partly filled with arenaceous material. In the eastern part of the district the development is more similar to that of Nes—Hamar.

Above the Orthoceras Limestone there is 6 m of nodular limestone grading into shale with limestone lenses. The lower part of these transition beds contains: *Megalaspis grandis*, the upper part: *Megalaspis gigas*. This indicates the presence of the upper beds of the Endoceras Limestone (3c γ).

The Upper Didymograptus Shale ($4a\ \alpha_{1\text{-}2}$), *the Ogyciocaris Shale* ($4a\ \alpha_3$) *and the Cephalopod Shale* ($4a\ \alpha_4$?). On account of the strong folding these shales are not well-preserved. A river section at Kolbu has dark shale with larger limestone-lenses containing a typical *Ogygiocaris* fauna of the Oslo type:

Ogygiocaris dilatata sarsi, Pseudomegalaspis patagiata, Trinucleus foveolatus, Nileus armadillo.

The Cephalopod Shale ($4a\ \alpha_4$?) with its round limestone nodules is exposed along the Lena and Hekshus rivers.

The Robergia Beds ($4a\ \beta$—$4b\ \alpha$). The name of these beds has been suggested by Skjeseth. Holtedahl mentioned the same beds as grey shale with thin beds of arenaceous limestone and quite small limestone lenses. The Robergia Beds which are better known from the other Mjøsa districts, evidently occur and form the basement of large parts of the covered land of Toten. In the section along the Bøver river, beds of calcareous sandstone are common up to the characteristic thick arenaceous beds of the next zone. (Holtedahl l.c. p. 15).

The Coelosphaeridium zone ($4b\ \beta$?). The lower part consists of shale with thick beds of arenaceous limestone. The upper shaly part of this zone is described by Holtedahl (l.c. p. 26) from Eina. The grey shale, mostly prismatically jointed, weathers to a characteristic brown to brownish-red colour, sometimes displaying a bluish tint. The thickness of the zone is difficult to establish.

The shale is highly fossiliferous, characteristic forms are:

Coelosphaeridium cyclocrinophilum, Mastopora concava, Chasmops cf. *conicophthalma, Illaenus glaber, Platystrophia biforata, Actinomena* cf. *asmusi, Diplotrypa* sp.

The Cyclocrinus zone ($4b\ \gamma$?). The development not studied much in detail, seems to be similar to that of the Nes—Hamar district.

The Mjøsa Limestone ($4b\ \delta$ +). Like the Encrinite Limestone of the Langesund—Gjerpen and Sandsvær districts, this limestone terminates the Middle Ordovician Series. Being rather pure, and having a thickness of more than twice that of the Encrinite Limestone, the Mjøsa Limestone has a considerable commercial value, a fact

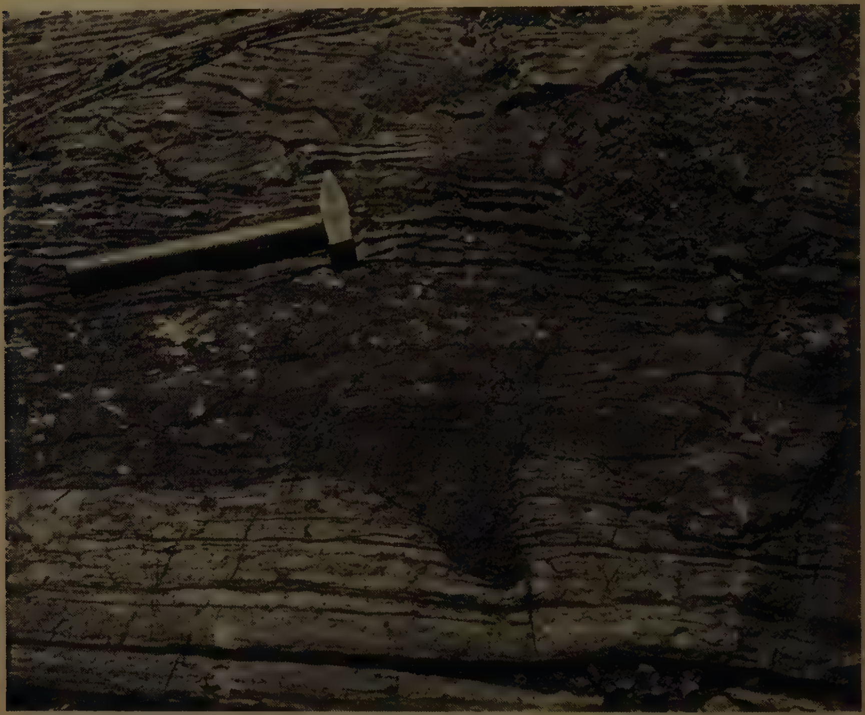


Fig. 10. Erosion furrows and overlying breccia in the Mjøsa Limestone of Ånerud, Toten. Skjeseth phot.

which is demonstrated by the many quarries scattered all over the country (Holtedahl 1912).

The conception of the age of the Mjøsa Limestone has changed from time to time. The limestone is not succeeded by the Lower Tretaspis Shale (4c α) such as the limestone of the southern district. A Silurian sandstone of Llandoverian age rests directly on the Mjøsa Limestone. Largely because of its coral faunas, the limestone was at first correlated with the Gastropod Limestone (5a) at the very top of the Ordovician elsewhere in the Oslo Region (Kiær 1897, Holtedahl 1909). Raymond (1916) and later Kiær (1920, 1921, 1926) formed, however, another opinion on the stratigrapical position of the Mjøsa Limestone. From a comparison with the Baltic regions, it became apparent that the limestone belonged rather to the Middle Ordovician,

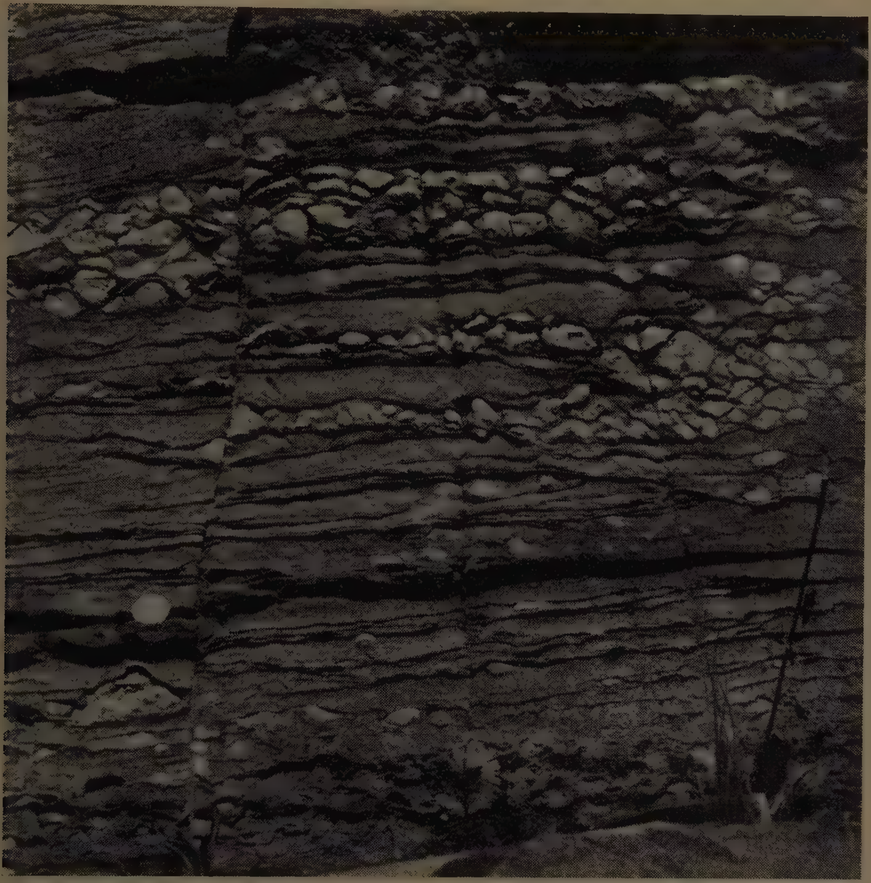


Fig. 11. Solenopora beds in the Mjøsa Limestone near Hundselv, Toten. Skjeseth phot.

largely contemporaneous with the Upper Chasmops Limestone (4b δ) of Oslo.

In the Toten District the Mjøsa Limestone is well exposed in several quarries N of Eina. As a representative section, the one occurring in the quarry at Ånerud (Sk), might be chosen.

The Mjøsa Limestone has a thickness of 100 m (99.80 m). The lower 80 m consist of compact grey, partly crystalline limestone and to a small extent (upper part) of bedded limestone of a reddish colour. Above this there is about 1 m (0.90 m) of dark arenaceous shale, and then 6.5 m with compact "reticulate" limestone intersected by numerous minor stylolites at different levels.

At the top of the "reticulate" limestone, a marked erosion surface occurs (fig. 10). Erosion furrows up to 15 cm in depth, penetrate into the limestone. The sediment filling the furrows and covering the limestone in general, consists of about 6 m of crossbedded arenaceous limestone breccia. This sediment is again succeeded by 6 m of compact limestone with numerous minor stylolites.

The upper surface of the Mjøsa Limestone shows very interesting features (Sk). Prior to the deposition of the overlying Silurian sandstone, the limestone has been subject to considerable erosion. Especially in the quarry at Kyset thick veins of the characteristic yellow-weathering Silurian sandstone penetrates deep into the underlying sandstone. A perfect Presilurian Karst erosion is demonstrated. The fissures and "tunnels" go down to at least 2.80 m below the surface of the limestone.

The fossil content of the Mjøsa Limestone of the Toten District is chiefly confined to *Solenopora* sp. which occurs in abundance through out the zone (fig. 10).

At Ånerud a few corals and stromatoporoids occur near the top of the limestone and in the road cut of Holte a coral reef limestone, 2 m thick, comes between beds with *Solenopora*. According to determinations by Hill (1953) the reef limestone contains: *Liopora favosa* and *Eofletcheria subparallella*. The corals are associated by stromatoporoids and *Solenopora* (Sk).

10. THE NES—HAMAR DISTRICT.

The island of Helgøya and the Nes peninsula N of it, are bordered on the N by the Permian horst of Precambrian rocks. No major fault seems to separate Nes from Hamar and Furnes on the E side of the lake (Sk).

Good exposures are found particularily along the railway N of Hamar and along the shore of the lake. The southern shores of Helgøya have been the hunting grounds for good fossils ever since the time of Leopold v. Buch.

Due to the strong Caledonian folding, the more incompetent beds in particular, are considerably compressed and distorted, making it very difficult to obtain continuous stratigraphical sections. It is

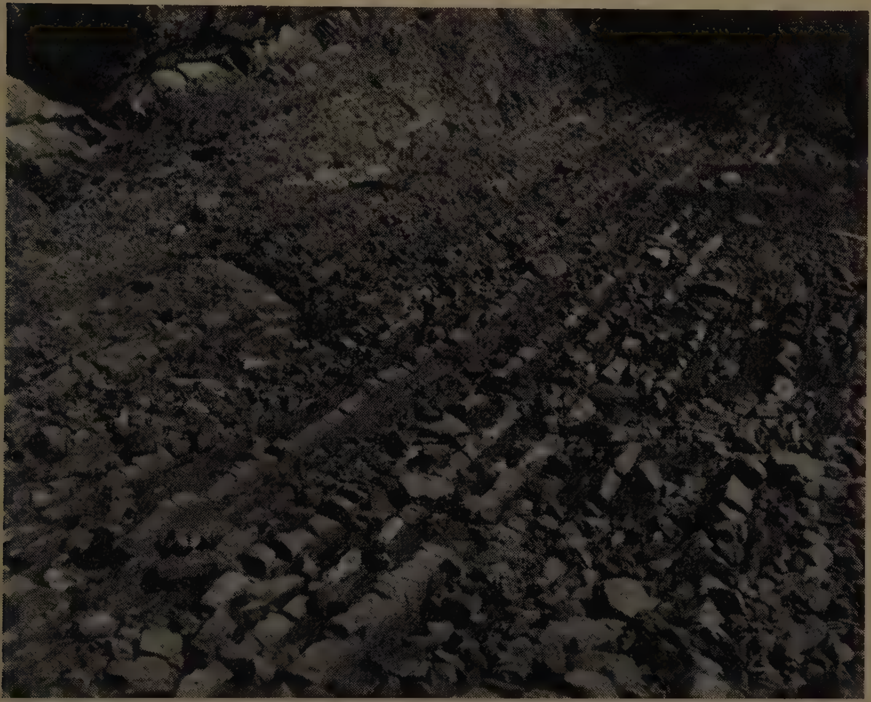


Fig. 12. Shales and limestone beds (inverted) forming the upper part of the Endoceras Limestone (3c γ) at Holmen, Helgøya. Skjeseth phot.

to be noted, however, that below the large, open synclines of the competent Mjøsa Limestone the shales have been little disturbed and consequently offer good opportunites for more detailed stratigraphical studies.

The basal transition beds (3c γ). These beds might be studied at Helskjær, Helgøya, at the church of Furnes, and at Fura, Løten.

At Helskjær, Helgøya (Sk), the Orthoceras Limestone (3c) shows an Oslo development, different from that of Toten. A L mbata Limestone (3c α) of 1.2 m, is succeeded by Asaphus Shale (3c β) of 1.1 m and further by an Endoceras Limestone (3c γ) of which he compact lower part is 1.2 m thick. Above the compact Endoceras Limestone with endoceratids there is 1 m of nodular limestone and above that 3 m of shale and limestone with *Megalaspis grandis* and

Asaphus striatus. These beds are further succeeded by 1.5 m of shale with continuous limestone beds containing *Megalaspis gigas*. Overlying beds of shale with limestone lenses, 0.5—1 m in thickness, carry underterminable trilobite fragments.

The development of 3c γ is thus similar to that of Hadeland N.

At the church of Furnes (Sk) the Endoceras Limestone is succeeded by a shale with limestone lenses containing a rich fossil fauna. The fossils are found in one layer of limestone lenses 4 m above the top of the compact Endoceras Limestone and 1 m below a dark shale which probably belongs to the overlying Upper Didymograptus Shale (4a α_{1-2}).

The fauna (Sk) is a peculiar mixture of the Orthoceras Limestone (3c) and Ogygiocaris Shale (4a α) faunas:

Megalaspis cf. *grandis*, *M. gigas*, *Niobe frontalis*, *Ampyx nasutus* *Asaphus* sp., *Ampyx mammilatus*, *Nileus armadillo*, *Ogygiocaris* cf. *dilatata*, *Trinucleus* sp. and *Telephus mobergi*.

The species listed as *Megalaspis* cf. *grandis* might represent a transition between *M. grandis* and *M. gigas*.

The first four species point to the Orthoceras Limestone, while the last five ones rather suggest the higher Ogygiocaris Series.

Most of the species listed may occur in one single limestone lens thus excluding the possiblility of a tectonic mixture of several zones.

At Fura, Løten (Sk), a locality in the eastern part of the Hamar district, the Orthoceras Limestone appears as a 6—8 m thick reticulate limestone, resembling the development at Toten rather than that at Helgøya and Hamar.

Above the compact Orthoceras Limestone, which is strongly deformed by tectonic pressure, there is a shale with lenses possibly 4 m thick, possessing *Megalaspis gigas* indicating the top layers of 3c γ.

The Upper Didymograptus Shale (4a α_{1-2}) and the Ogygiocaris Shale (4a α_3). The black shale with the limestone lenses is exposed in several localities, i.a. along the shore of Helgøya. The shale itself is too badly preserved to offer determinable graptolites. Our knowledge of the shale is therefore confined to the upper part with the fossiliferous limestone lenses.

The lenses or ellipsoids are mostly flat, having a diameter of 30—40 cm and consisting of bluish-black, fine-grained limestone

(Holtedahl 1909 p. 45). Characteristic of the lenses are the numerous baryte crystals on the surface.

The thickness of the shale is quite uncertain, but Holtedahl suggests 20—30 m as being possible.

The shale contains a typical *Ogygiocaris*-fauna of the Oslo-type. *Ogygiocaris dilatata sarsi*, *Pseudomegalaspis patagiata*, *Nileus armadillo*, *Ampyx mammilatus*, *Trinucleus foveolatus*, *Telephus bicuspis*, *T. mobergi*, and *Triarthrus* sp.

3—4 m of nodular limestone layers follow above the shale. Few fossils, among them *Nileus armadillo*, are present.

The Cephalopod Shale (*4a* α_4*?*). The black shale contains limestone lenses different from those of the Ogygiocaris Shale. The lenses are more rounded, less flat, and the barytes appears as irregular protuberances on the surface. Pyrite concretions often representing individual fossils, are common in the shale.

The fossil fauna is very characteristic, consisting chiefly of cephalopods and gastropods:

Orthoceras sp. div., *Trocholites* sp. div., *Lituites lituus*, *Pleurotomaria? hyperborea*, *Raphiostoma schmidti*, *Lytospira norvegica*. Of trilobites have been recorded: *Ogygiocaris dilatata* (rare), *Robergia microphthalma*, *Nileus armadillo*, *Asaphus* sp. div.

The thickness of the shale is unknown, but seems to be very considerable.

The Robergia Beds (*4a* β*—4 b* α). The black Cephalopod Shale is succeeded by a coarser grey shale with thin, usually less than 2 cm thick, calcareous sandstone beds and scattered, regular limestone lenses of small size (5—8 cm in length). In the Nes—Hamar district only a few gastropod fragments have been found (Holtedahl l.c. p. 10).

The thickness of this shale is unknown but evidently very considerable.

The Coelosphaeridium Zone (*4b* β *?*). At Helgøya (Holmen) the Robergia Beds with its thin arenaceous beds, is succeeded by shale with up to 20—30 cm thick arenaceous limestone beds. In these beds Holtedahl found traces of *Coelosphaeridium* and *Diplotrypa*. Similar beds occur N of Hamar and the upper beds are also exposed here. The upper part of the shale has less arenaceous and thinner limestone bands.

The beds are fossiliferous and the following species may be mentioned as being typical:

Coelosphaeridium cyclocrinophilum, *Platystrophia lynx*, *Diplotrypa* sp., *Mastopora concava*.

In addition to these common forms, there are *Pterygometopus*, *Actinomena* cf. *asmusi* etc.

The thickness of the zone is unknown, but probably very considerable.

The Cyclocrinus Zone (*4b γ?*). The classical section is the railway cutting at Furuberget N of Hamar. Below a syncline of Mjøsa Limestone the *Cyclocrinus*- and parts of the *Coelosphaeridium* zones are exposed.

According to Holtedahl the Cyclocrinus Beds may be divided into a lower shale with limestone beds and an upper bedded limestone. Above this there is shale with arenaceous limestone beds which Kiær (1897) and Holtedahl (l.c.) included in the Mjøsa Limestone, although the latter mentions (p. 33) that is should rather belong to the Cyclocrinus Beds. More recent studies of the section (Sk) confirm the inclusion of the beds in the Cyclorinus Beds, a view applied in this paper.

A lower boundary of the *Cyclocrinus*-zone is not at all well marked. Holtedahl presents 15 m of dark-grey shale with calcareous sandstone below the bedded limestone. *Coleosphaeridium* occurs, however, 7.20 m below the limestone (Sk), a fact which makes it difficult to draw the line.

The bedded limestone has characteristic grey, partly arenaceous parallel limestone beds, about 10 cm thick, alternating with a few cm of shale. The thickness of the limestone is 8 m.

The upper part of the *Cyclocrinus*-zone (previously regarded as belonging to the Mjøsa Limestone) consists of shale with calcareous sandstone beds sometimes cross-bedded, and beds of purer limestone. In the uppermost part, the limestone beds attain a thickness of 30—40 cm, forming a transition to the Mjøsa Limestone above.

Fossils are more or less common throughout the zone. In the shale below the limestone, the following species are characteristic:

Sowerbyella sericea, *Chasmops* cf. *bucculenta*, *Pterygometopus kuckersiana*, *Actimonena* cf. *asmusi*, *Platystrophia* sp., *Diplotrypa* sp. and less common: *Cyclocrinus* sp.

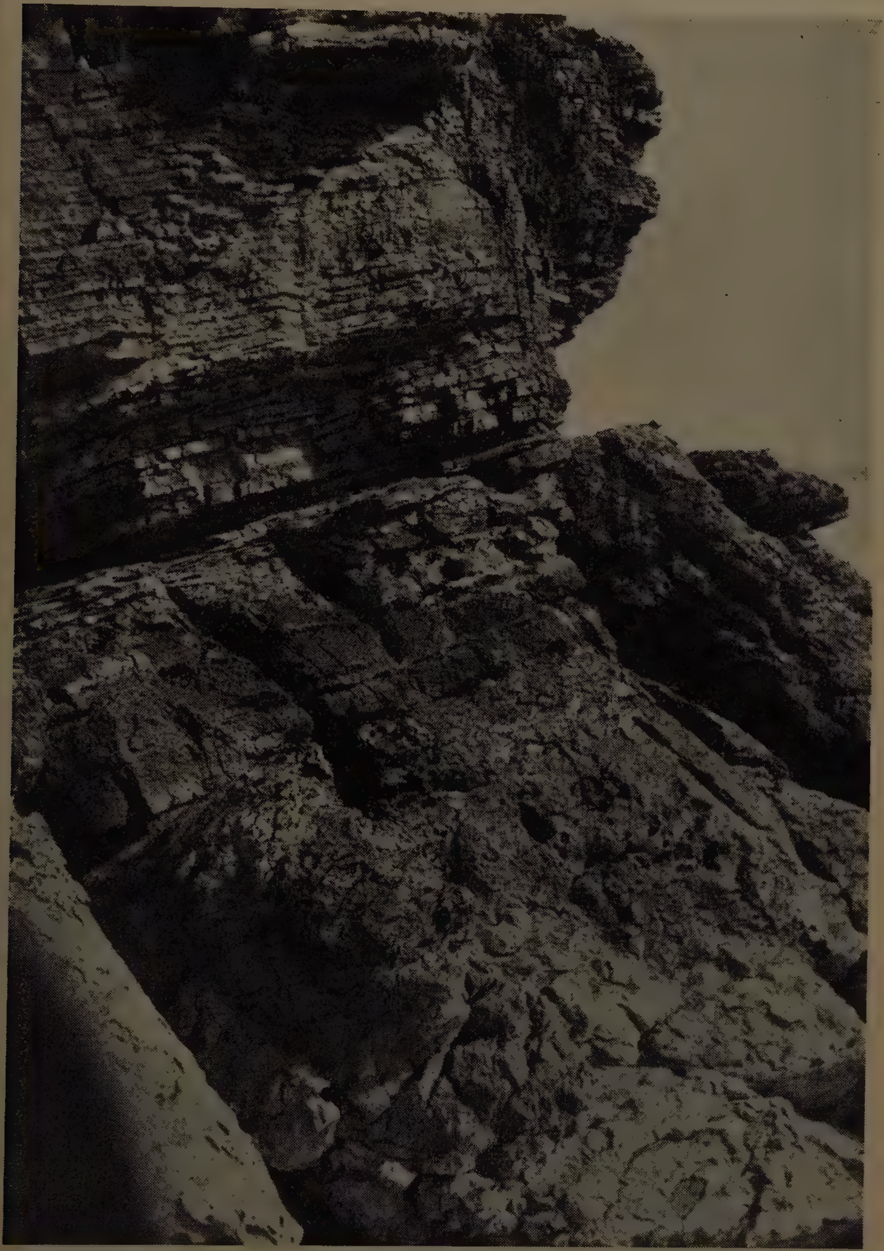


Fig. 13. The Mjøsa Limestone at Bergvika, Helgøya. The lower part of the section is here developed as a reef limestone. Skjeseth phot.

In the limestone:

Cyclocrinus sp. div., *Sowerbyella sericea, Chasmops maxima, C.* cf. *bucculenta, Illaenus glaber, Platystrophia* (small form), *Crania* sp. and *Actinomena* cf. *asmusi.*

In the upper shale:

Sowerbyella sericea, Chasmops cf. *bucculenta, C.* sp., *Actinomena* cf. *asmusi, Platystrophia* sp., *Diplotrypa* sp. and *Cyclocrinus* sp. New forms are (according to Kiær and Holtedahl) i.a. *"Rhynchonella borealis", "Atrypa headi", Nicolella actonia* and the ostracod *Tallinnella kiaeri* Henningsmoen (1953.).

The Mjøsa Limestone (*4b* $\delta+$). The classical exposures are Helgøya and Furuberget (Kiær 1897).

On Helgøya the limestone forms a syncline well exposed in Bergsvika. Of particular interest is the strong development of the stromatoporoid reefs (fig. 13, 14). As might be expected the reef facies has a rather local development. Recent studies (Sk) demonstrate variations in thickness on either side of the syncline. In the following the measurements pertain to the southern branch of the syncline, while the northern values are given in ( ).

Above a basal limestone of 1 m (2 m) with *Solenopora* there is 5 m (2 m) of arenaceous limestone partly developed as a sedimentary breccia with corals.

The following 9 m (10) is developed as a spectacular stromatoporoid reef with corals.

Above the reef there is an arenaceous limestone breccia of 2 m (4 m) with corals marking the extinction of the reef. An overlying dark *Solenpora*-limestone of 1 m (0.5 m) passes into a limestone of 1.5 m (2.0 m).

Then follows 17 m (12.5 m) of fossiliferous bedded limestone with some shale between the beds. The uppermost part is developed as 10 m (10 m) of compact reticulate limestone resembling the Masur Limestone of Sweden (Sk).

The section exposed comprises 41 m, but this represents only the lower part of the Mjøsa Limestone.

The characteristic fossils are:

Solenopora compacta, Stromatopora sp., *Eofletcheria subparallela* Hill (1953), *Liopora favosa* and *Nyctopora* aff. *parvotubulata.*

At Furuberget the complete thickness of the Mjøsa Limestone is

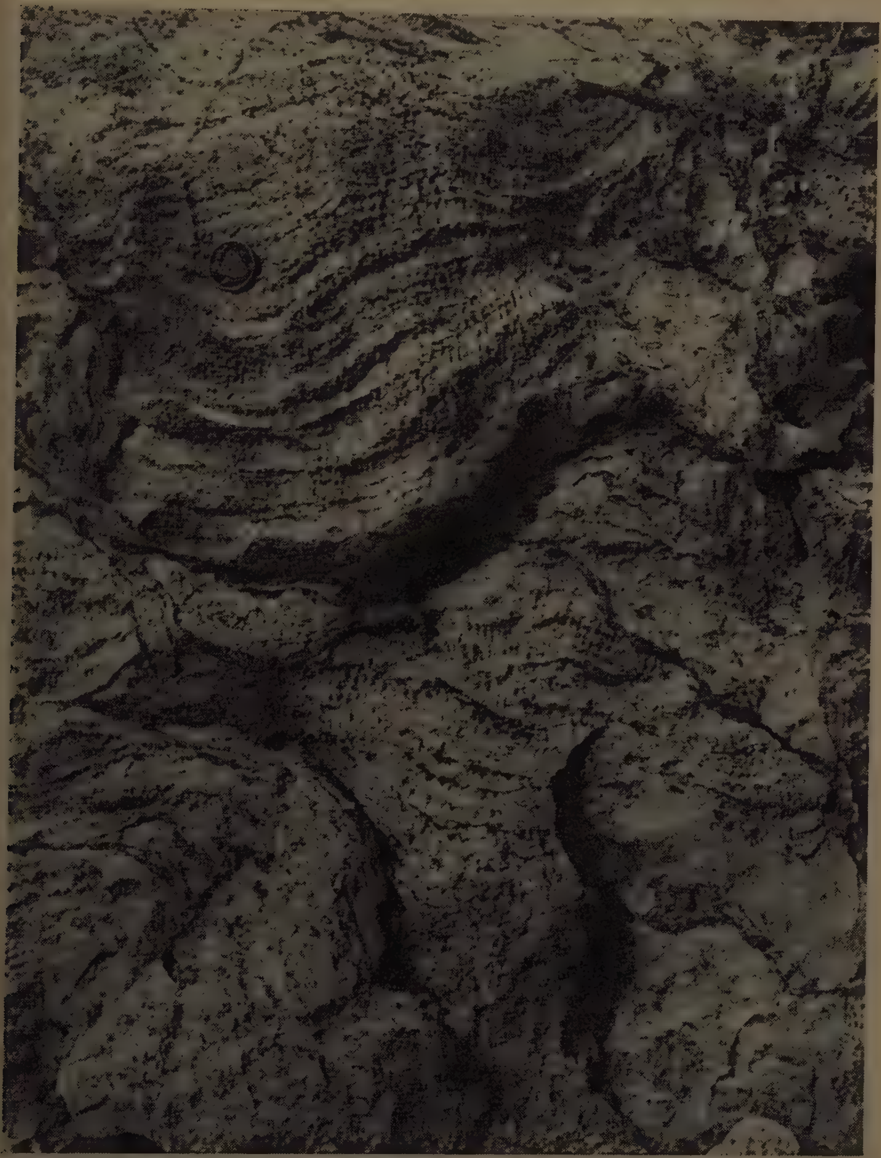


Fig. 14. Detail of the stromatoporoid reef in the Mjøsa Limestone of Bergvika, Helgøya. Skjeseth phot.

exposed. The upper compact part is quarried. The section is as follow (Sk):

The lower 16.8 m consist of compact, partly bedded limestone with *Solenopora* sp. Then follow 2 m with compact *Solenopora* limestone showing numerous corrosion surfaces or minor stylolites.

A calcareous fragment layer of 0.20 m contains stromatoporoids and corals, and evidently represents the remains of the reefs so conspicuous further SW.

The upper 61 m form a compact limestone of which the upper 40 m are practically without fossils.

The complete thickness of the Mjøsa Limestone of the Nes—Hamar district is 80—85 m.

11. THE RINGSAKER DISTRICT.

This district, comprising the southern part of the Ringsaker parish and smaller parts of Veldre and Furnes, has lake Mjøsa on the W side, the horst and the Brumund Valley forming the SE—E boundaries. To the N, the boundary is less distinct. The "Ringsaker-inversion" with the appearance of Eocambrian sediments, forms a more or less artificial boundary.

In spite of being farther N, the Middle Ordovician sediments including the shales, are fairly well preserved. Good exposures are found in many places especially along the Railway (Fangberget).

The basal transitional beds (*3c* γ). The Orthoceras Limestone has a development similar to that of Toten. The compact limestone has the characteristic reticulate surface. The thickness, however, is much greater, being not less than 40 m (Sk). Visible fossils are scarce and it is therefore hardly possible to decide which zone or subzone constitutes the top layer of the limestone. Endoceratids are common 10—15 below the upper surface.

No transitional layers are found between the top of the compact limestone and the black shale above. Although transitional zones or subzones may be concealed in the limestone itself a comparison with the conditions at Toten makes this less probable.

The Upper Didymograptus Shale (*4a* $\alpha_{1\text{-}2}$). At Tande railway station Bjørlykke (1905 p. 20) found *Glyptograptus teretiusculus* and *Climacograptus scharenbergi* and later on Holtedahl (1909 p. 13) found

Didymograptus geminus indicating the *geminus* zone 4a α_2. The thickness of the black Upper Didymograptus Shale is unknown. The absence of the shale in certain localities may be due to tectonics.

The Ogygiocaris Shale (*4a* α_3). This shale probably has the same lithology and fossils as in the district further S. Possibly a shelly facies (*Ogygiocaris*-fauna) may appear somewhat earlier than in Oslo.

Characteristic fossils are:

Ogygiocaris dilatata sarsi, *Trinucleus foveolatus*, *Nileus armadillo*, *Telephus bicuspis* and *Triarthrus* sp.

The thickness of the zone is unknown.

The Cephalopod Shale (*4a* α_4?) The presence of this zone is suggested by the characteristic lenses with irregular protuberances. The zone of which a greater part may be absent, has not been particularly studied in the district.

The Robergia Beds (*4a* β—*4b* α). New sections (Sk) have considerably extended our knowledge of the grey shale with thin calcareous sandstone beds and small lenses.

At Heramb the following fossils have been found in the shale:

Robergia microphthalma, *Pseudomegalaspis patagiata*, ostracods, and the following graptolites determined by Dr. Bulman: *Corynoides* cf. *curtus*, *Glyptograptus teretiusculus euglyphus?*, *Amplexograptus* aff. *vasae*, and *Diplograptus* sp.

A more complete section is found in the cutting of the Brumund river at Holmen.

The base of this section is formed by 10 m of Cephalopod Shale changing from black to a grey colour up towards the lower boundary of the Robergia Beds.

The lower 28 m consist of grey shale with calcareous sandstone beds and lenses with *Ampyx costatus* and *Nileus armadillo* in the lower part and some graptolites at the top. Then there follow 7 m of shale with scattered small lenses. The next 13 m of shale have thin beds of calcareous sandstone. The fossil fauna comprises:

Robergia microphthalma, "*Megalaspis*" sp., *Dionide* sp.

The following graptolites have been determined by Dr. Bulman from this and the lower part of the section:

Dicellograptus sextans exilis, *Climacograptus* ? *scharenbergi*, *C.* sp., *Amplexograptus* aff. *vasae* and *Lasiograptus* cf. *harknessi*. The next 7 m consist of shale with thick (20 cm) layers of cross-bedded calcareous sandstone. The upper 22 m comprise parallel beds of arenaceous limestone alternating with less shale.

According to Dr. Bulman, the graptolite assemblage, occurring in the upper part of the section, suggests a horizon somewhat higher than the zone of *Nemagraptus gracilis*.

The Coelosphaeridium Zone (*4b β?*). The shale is well exposed at Fangberget and Tørud—Brattberg. In both localities the basal part of the zone may be missing; at least the coarse beds of calcareous sandstone, occurring on Helgøya in the Nes—Hamar District, are not known.

The Fangberget section is described by Holtedahl (1909 p. 23—26). The dark-grey, prismatically jointed shale has 5—10 cm thick beds of more or less arenaceous limestone weathering to a characteristic reddish-yellow (rusty) colour. The thickness of the shale between the limestone beds amounts to 1/3 to 2/3 m.

Already in the lower beds, species of *Coelosphaeridium* and *Mastopora* appear. The fairly rich fossil fauna is rather constant throughout the section which measures 40 m in thickness.

At Tørud—Brattberg (Sk) the section is somewhat disturbed, but the thickness of the zone seems also to be 40 m here. The sediments are similar to those of Fangberget. A characteristic arenaceous limestone band of 15 cm contains numerous *Coelosphaeridium*.

Characteristic fossils are:

Coelosphaeridium cyclocrinophilum, *Mastopora concava*, *Platystrophia lynx*, *Chasmops* cf. *bucculenta*, *C*. sp., *Illaenus glaber*, *Actinomena* cf. *asmusi*, *Porambonites* sp., *Orthis* sp., *Diplotrypa* sp. and pelmatozoan stems. *Cyclocrinus schmidti* occurs, but is rare. Graptolite fragments have been determined by Bulman as *Diplograptus* or *Amplexograptus* sp.

The Cyclocrinus Zone (*4b γ?*). At Fangberget this zone is practically not exposed between the Coelosphaeridium Shale and the Mjøsa Limestone. Holtedahl (l.c.) mentions, however, that traces of a zone with compact limestone (limestone beds) such as at Furuberget, are not found.

At Tørud—Brattberg (Sk) the Cyclocrinus Beds consist of grey, partly arneaceous shale with a few more or less arenaceous limestone beds. Minor sedimentary breccia, crossbedded sandstone and ripple marks indicate shallow conditions. At the top characteristic beds of 5—7 cm with pelmatozoan stems.

The thickness of the zone is only 12 m suggesting that the upper part of the zone is actually missing (Sk).

Characteristic fossils are:

Cyclocrinus sp., *Sowerbyella sericea, Chasmops* sp., *Actinomena* cf. *asmusi, "Rafinesquina"* sp.

The Mjøsa Limestone. (*4b* δ+). At Tørud—Brattberg (Sk) the 12 m of *Cyclocrinus* zone is followed by about 30 m of compact limestone with *Solenopora* sp. Besides this fossil, *"Rhynchonella borealis"* occurs near the base and cephalopod fragments higher up.

Above the 30 m of compact limestone there are 60—70 m of red calcareous shale containing pieces of the underlying limestone. The calcareous shale probably belongs to the Mjøsa Limestone. Except for a few specimens of *Obolus* sp. no fossils have been found.

The considerable hiatus above the Mjøsa Limestone is pointed out by the presence of a quartz conglomerate and an overlying quartzite assumed by Skjeseth to be equivalent to the Phacops Quartzite of Sweden.

ADDITIONAL DISTRICTS.

1. *Snertingdal.*

Middle Ordovician sediments are found in the district NW of Ringsaker, outside of the Oslo Region. The outcrops have not been studied in detail, but fossils have been found by Münster (1901), some of which were identified by Holtedahl (1909 p. 13) as:

Ogygiocaris dilatata sarsi, Trinucleus foveolatus and *"Aeglina"* sp. ? the latter probably *Telephus* sp. as mentioned by Hadding (1913).

The fossils which are preserved in limestone lense of the common type, prove the occurrence of the typical Ogygiocaris Shale of Oslo-type so far N. Münster (1901) found the *Ogygiocaris* beds to be succeeded by arenaceous beds up to 5—6 m in thickness.

2. *Hedmarks-vidda.*

Scattered occurrences of the Middle Ordovician are also found NW of the Ringsaker District. Bjørlykke (1905 p. 33) mentions the occurrence of *Ogygiocaris dilatata* at Brennseter. A closer study of these outcrops has not yet been carried out.

Comparison of the various district and the sequences correlated with the international graptolite time scale.

A more detailed and reliable correlation of the strata within the Oslo Region has to be postponed until the majoı part of the fossils has been satisfactorily described. At present however, one may draw certain conclusions from the facts already available. The correlation has largely to depend on a few better known fossils and, to some extent, also on the lithology.

Thanks to Dr. Bulman's determinations of the graptolites, it has been possible to establish the age of our Middle Ordovician zones. In particular, the Oslo—Asker section has permitted a closer correlation with the graptolite sections of Great Britain and Sweden (Scania).

Characteristic of the sequences of the Oslo Region is the considerable variation in lithofacies. On one side, we have the typical black graptolite shales and, on the other side the characteristic reef limestone. Between these extremes we have all types of transitions. A mixed graptolite and trilobite facies is of considerable importance in fixing the age of the zone. Sandy facies is significant in connection with tectonics. Different facies, meaning the change in lithofacies within one stratigraphical unit, is also common. It is difficult, however, to be sure that a difference of lithofacies actually comprises one and the same stratigraphical unit. Our studies of the sections give the impression that numerous smaller hiatuses are present, suggesting in several cases, that one distinct lithofacies might be contemporaneous with a hiatus rather than with another lithofacies of about the same age.

The fossil assemblages naturally change with the different lithofacies. The present studies have also indicated the presence of vicarous forms within apparently similar facies. We might mention the two types of *Ogygiocaris dilatata* and their associating faunas.

A rapid change in lithofacies is often found in the sections. A graptolite shale may be succeeded, apparently without transition, by a limestone with a trilobite-brachiopod fauna. The rapid change

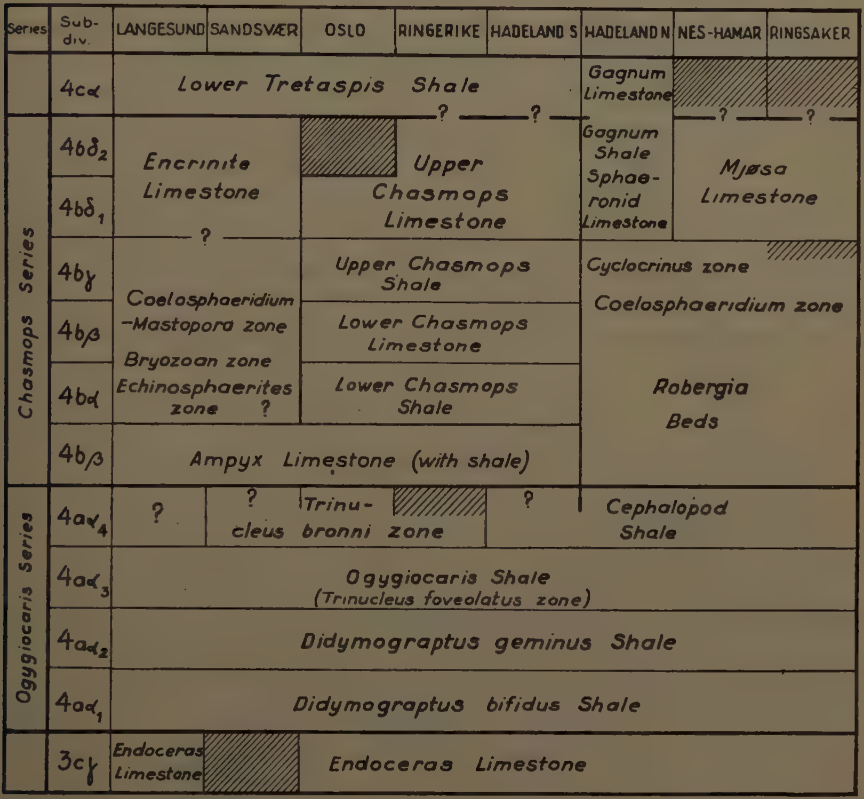

Series
Sub-div.
LANGESUND
SANDSVÆR
OSLO
RINGERIKE
HADELAND S
HADELAND N
NES-HAMAR
RINGSAKER
4cα
Lower Tretaspis Shale
Gagnum Limestone
4bδ2
4bδ1
Encrinite Limestone
Upper Chasmops Limestone
Gagnum Shale
Sphaeronid Limestone
Mjøsa Limestone
Chasmops Series
4bγ
4bβ
4bα
Coelosphaeridium–Mastopora zone
Bryozoan zone
Echinosphaerites zone
Upper Chasmops Shale
Lower Chasmops Limestone
Lower Chasmops Shale
Cyclocrinus zone
Coelosphaeridium zone
Robergia Beds
4bβ
Ampyx Limestone (with shale)
Ogygiocaris Series
4aα4
Trinucleus bronni zone
Cephalopod Shale
4aα3
Ogygiocaris Shale (Trinucleus foveolatus zone)
4aα2
Didymograptus geminus Shale
4aα1
Didymograptus bifidus Shale
3cγ
Endoceras Limestone
Endoceras Limestone
?

Fig. 15. Regional development of the Middle Ordovician of the Oslo Region. (Read 4a β, not 4b β, for the Ampyx Limestone).

does not need to signify a hiatus of some kind. Slight hydrographic alterations may have caused better ventilated conditions (comp. Strøm 1936).

In designating the stratigraphical units (fig. 15), the previously established names have been used as far as possible. It may perhaps be emphasized that local names would have been preferable to names such as "Ampyx Limestone", but since this type of designation is so well established in the Baltic—Scandinavian Ordovician it could be maintained to a reasonable extent.

When a zone is developed as a graptolite shale it is given the name of the corresponding graptolite zone of the British or Swedish section. Frequently, one part of a zone is developed as a graptolite shale while the rest comprises limestone beds with a shelly fauna. In this case the two lithofacies represent parts of one zone only. The designation of such a part of a zone may meet with difficulties. The lower, graptolite part of the *Didymograptus hirundo*-zone is here called 3b ε, while the rest of the zone evidently corresponds to 3c α-γ.

In the following, the different zones are treated cronologically. In order to fix the lower and upper boundaries of the Middle Ordovician, it is necessary to consider and discuss the series immediately below and above.

THE BASE OF THE MIDDLE ORDOVICIAN.

As mentioned above, the Upper Didymograpthus Shale rests on the transition beds above the Orthoceras Limestone.

In order to date the Orthoceras Limestone it is necessary to investigate the underlying Lower Didymograptus Shale (3b). Usually the graptolite shale changes abruptly into the Megalaspis Limestone (3c α) forming the base of the Orthoceras Limestone. This is, however, not always the case. As shown by Skjeseth (1953a) a different development is found in Ringsaker. The upper part of the Lower Didymograptus Shale here is developed as shale with limestone lenses containing a trilobite fauna older than that of the true Orthoceras Limestone (Pl. 5). In the Langesund district the shale is missing; the Orthoceras Limestone, probably a higher part of it (3cγ), rests on alum-shale of the Uppermost Cambrian and at Sandsvær the Asaphus Shale (3c β) seems to rest on the Upper Cambrian and the Endoceras Limestone (3c γ) to be missing (Hz).

The Lower Didymograptus Shale (3b).

The shale between the Ceratopyge Limestone (3a γ) and the Megalaspis Limestone (3c α), has been studied by Monsen (1937), who suggests the following division of the zone (or zone complex rather):

Subzone of	*Phyllograptus angustifolius elongatus*	3b δ
—»—	*Phyllograptus densus*	3b γ
—»—	*Didymograptus balticus* (3b β_2)	3b β
	Didymograptus validus (3b β_1)	

Subzone of { *Tetragraptus approximatus* (3b α_2) . . 3b α
Tetragraptus phyllograptoides (3b α_1)

From Galgeberg, Oslo, Monsen (1937 p. 80) mentions the occurrence of *Didymograptus hirundo* in the upper part (uppermost 0.60 m) of the subzone 3b δ. The species has also been recorded at Slemmestad (l.c. p. 86).

Recent studies of the Slemmestad section (Sp) have furnished new information on the shale immediately below the Orthoceras Limestone. Above the zone 3b δ with *Phyllograptus augustifolius elongatus* there occur 4.5 m of shale, the lower 2 m being black and the upper 2.5 m grey. The section is as follows:

at 4.5 m, base of Megalaspis Limestone 3c α.
» 3.5 m, *Didymograptus hirundo* and biserial graptolites.
» 2.5 m, *Didymograptus hirundo,* extensiform Didymograpti, *Isograptus gibberulus* and biserial graptolites.
» 1.5 m, *Didymograptus hirundo, Trochograptus difusus, Phyllograptus* sp. and biserial graptolites.
at 0 m, *Phyllograptus angustifolius elongatus, Phyllograptus* sp., *Isograptus gibberulus norvegicus* (= *I. caduceus norvegicus*), extensiform Didymograpti and biserial graptolites.

The specimens of *Isograptus gibberulus* being described in a later paper by Spjeldnæs (1953) appear to correspond to the typical British specimens and deviate from *I. g. norvegicus* of the zone 3b *d*.

A comparison with the classical British sections gives us a clue to the age of the beds immediately below the Orthoceras Limestone. According to Monsen (1937 p. 258) the British zone of *Didymograptus extensus* corresponds to the three zones 3b β, 3b γ, and 3b δ of the Norwegian section. Elles (1933) divides the *extensus*-zone into four subzones:

Zone of *Didymograptus hirundo*
Zone of *Didymograptus extensus.* { Subzone of *Isograptus gibberulus.*
—»— *Didymograptus nitidus.*
—»— *Didymograptus deflexus.*
—»— *Tetragraptus* (reclined).

The uppermost subzone contains the typical *Isograptus gibberulus*, apparently identical to the species at Slemmestad, and transient forms such as *Didymograptus nitidus-hirundo*.

The overlying zone of *Didymograptus hirundo* "is marked by the true broad *D. hirundo*, accompanied by many *D. hirundo-nitidus* transients" (Elles 1933 p. 97).

While the occurrence of *Isograptus gibberulus* might point to the upper subzone of the *extensus*-zone, the abundant appearance of the true *Didymograptus hirundo* strongly suggests the *hirundo*-zone. *Isograptus gibberulus* seems to be able to continue upwards into the *hirundo*-zone. This is evidently the case in Sweden (Elles 1933 p. 107, and Monsen 1937 p. 258b) where it occurs, though with a more broad-branched form, in the Lower Asaphus Limestone (Holm 1895).

The section at Slemmestad, Asker, suggests the presence of the lower part of the zone of *Didymograptus hirundo* below the Megalaspis Limestone, the basal zone of the Orthoceras Limestone (3c).

Since parts of the *hirundo*-zone appear to be present above the zone of *Phyllograptus angustifolius elongatus* (3b *δ*), it seems reasonable to introduce a new designation for this lower part of the *Didymograptus hirundo* zone in the Oslo—Asker District. As part of the Lower Didymograptus Shale it may be called the zone of *Didymograptus hirundo* (pars) = 3b *ε*.

The Orthoceras Limestone with the transition beds (*3c*).

In the Oslo—Asker district the limestone comprises, as mentioned above, 1. the Megalaspis Limestone (3c *α*), 2. the Asaphus Shale (3c *β*) and 3. the Endoceras Limestone (3c *γ*).

With an exception of the uppermost transition beds the Orthoceras Limestone (3c) has a rather uniform development in most districts of the Oslo Region. The Oslo-development is found at Sandsvær Ringerike, Hadeland and Nes—Hamar (except at Løten). At Langesund and Sandsvær on the other hand, parts of the limestone are missing, and at Toten and Ringsaker (and Løten) the Orthoceras Limestone rapidly increases in thickness and instead of the three "lithological" zones, we find one compact limestone with a characteristic "reticulate" pattern.

More pronounced variation is found in the development of the upper beds of the Endoceras Limestone (3c *γ*) i.e. the transitional beds between the Orthoceras Limestone and the overlying Upper Didymograptus Shale.

In Oslo—Asker the upper part of the compact Endoceras Limestone contains the characteristic trilobites *Megalaspis grandis*[1] and *Asaphus striatus*. Arenaceous beds above contain *Asaphus*-fragments which probably belong to species characteristic of the *gigas*-zone in Sweden (Jaanusson). A subzonal division of the Endoceras Limestone (3c γ) is more conspicuous in the northern districts. In Hadeland, Toten and Nes—Hamar, the compact Endoceras Limestone with *Cyclendoceras* and *Vaginoceras* sp.div. is succeeded by 3—6 m of shale and limestone with *Megalaspis grandis* and *Asaphus striatus*. In Eiker, Brøgger (1882 p. 29) distinguishes a separate upper part of the Endoceras Limestone with the guide fossil of *Megalaspis grandis*. (In the Langesund—Gjerpen and Nes—Hamar districts, mixed faunas occur which will be discussed below). The characteristic beds with *Megalaspis grandis* may probably be distinguished as a separate subzone such as in Sweden, but this has to be postponed until a more detailed study of the Orthoceras Limestone has been accomplished.

Both at Hadeland (N) and Helgøya the *grandis*-zone is succeeded by a few meters (3 m and 1.5 m) of shale with limestone lenses containing the characteristic *Megalaspis gigas*. This species is also found at Langesund, Eiker, Oslo (Brøgger 1882), and Nes—Hamar. Just as in Sweden these beds with *Megalaspis gigas* also evidently form a separate subzone (or zone).

The local distribution of the transitional beds. As shown in Pl. 5 the beds vary considerably in thickness from place to place and even seem to be more or less absent in certain localities. The most complete development is to be found in the NW part of the Oslo Region, at Ringerike (?), Hadeland, Toten, Helgøya. In Oslo—Asker and particularly at Langesund, the beds are but slightly developed, and at Sandsvær, both the Endoceras Limestone and the transition beds may be absent (actual transition not well exposed). The thick, compact Orthoceras Limestone of Ringsaker is succeeded by *Ogygiocaris* beds, but this may be due to the squeezing out of the soft Upper Didymograptus Shale. The occurrence, however, of typical *Cyclendoceras—Vaginoceras* layers about 10—15 m below the top may perhaps suggest higher beds included in the limestone.

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[1] The name refers to the species described by Sars (1935) (comp. Størmer 1940 p. 134). This species has been assumed by Holm (1882 p. 89) and others to be a synonym of *Megalaspis centaurus* ("*Asaphus Centaurus*") deescribed by Dalman (1826) from Ormøga in Alebøke on Öland, Sweden. The fragments described by Dalman (fragments of large free cheeks) are possibly too little known to maintain Dalman's species as a valid species. *M. grandis* = *centaurus* occurs on Öland in beds below those with the related form *M. gigas* (Bohlin 1949). Both species belong to one *Megalaspis* group which also includes *M. rudis*. Angelin's (1854) and Steinhardt's (1874) use of Dalman's specific name for a species of *Illaenus* has caused some confusion. Holm (1882 p. 89) who became aware of this altered the name from *Illaenus centaurus* to *I. chiron*, and later on this was again changed to *I. schroeteri* (Westergård 1943). Because of the former name, the term "Centaurus Limestone" was previously used to signify the Schroeteri (= Chiron) Limestone, not the beds below the Gigas Limestone.

Mixed transtional faunas occur at Langesund and Furnes (Nes—Hamar). At Langesund a thin top-layer of the compact Orthoceras Limestone contains both *Megalaspis grandis* and *M. gigas*. At Furnes the two species and a characteristic mixed fauna occur in the same limestone bed in the shale above the compact limestone. The contemporaneous appearance may be explained in different ways: 1. The vertical ranges of the guide fossils overlap, causing mixed faunas in the transition between two zones. 2. The mixture may be due to a redeposition of an earlier non-consolidated fossiliferous sediment (similar to the occurrence of post-glacial shells together with recent ones along the present northern shores).

The changes in the development of the transitional beds suggest a time of unstable conditions. Local regressions with emergences took place, as suggested in the S districts. The trilobite limestone facies might have been replaced by graptolite-black shale facies to a certain extent. It is therefore possible that in certain localities the upper part of the Endoceras Limestone (3c γ) has been replaced by graptolite shale.

The age of the Orthoceras Limestone (*3c α—3c γ*).

The present finds of graptolites at the very top of the Lower Didymograptus Shale (3b ε) and at the very base of the Upper Didymograptus Shale (4a α_1), enable us to determine the relative age and duration of the Orthoceras Limestone (3c) in between.

The uppermost beds of the Lower Didymograptus Shale belong to the *Didymograptus hirundo* zone, showing that at least parts of this zone are present below the Orthoceras Limestone.

Above the Orthoceras Limestone there comes the zone of *Didymograptus bifidus*. *Phyllograptus nobilis*, characteristic of the lower subzone of the *bifidus* zone in Sweden (Ekström 1937 p. 47), occurs above *grandis-gigas* beds at Langesund, and above probable *gigas*-beds in Oslo—Asker (Pl. 5). This shows that also the lower part of the *bifidus* zone is present. A certain overlapping of the *gigas*- and *bifidus* zones probably exists, but is evidently so small that the boundary between the *bifidus-gigas* zones largely coincides with the boundary between the *bifidus* zone and the next graptolite zone below i.e. the zone of *Didymograptus hirundo.*

The Orthoceras Limestone (3c α—γ) of the Oslo Region is thus equivalent to a little less than one graptolite zone, i.e. the zone of *Didymograptus hirundo.*

This short duration of the Orthoceras Limestone, probably representing several trilobite zones or subzones, is rather surprising. The *hirundo*-zone is apparently a ''normal'' graptolite zone. In Great Britain (Elles 1933) the graptolite assemblages of the zone show a moderate and gradual development from the base to the top of the zone, a fact indicating a ''normal'' duration and no interruption of any importance during the sedimentation.

The correlation indicated in fig. 16 deviates considerably from the current views on the duration of the interval between the two Didymograptus shales. A hiatus (the Trysil emergence) and about two graptolite zones are generally assumed to be equivalent to the trilobite zones mentioned. In a recent publication Kautsky (1949) correlates the Norwegian Orthoceras Limestone (3c α—γ) with the graptolite zones of *Didymograptus extensus* (in fact comprising several subzones probably of zonal value), *D. hirundo* and *D. bifidus.*

THE OGYGIOCARIS SERIES.

The Upper Didymograptus Shale (*4a* α_{1-2}) *and the Ogygiocaris-bronni beds* (*4a* α_{3-4}).

The new graptolite finds, kindly determined by Dr. Bulman, have shown the presence of the zones of *Didymograptus bifidus* (4a α_1) and *D. murchisoni* (or rather *D. geminus*) (4a α_2). The lower part of the *bifidus*-zone, the subzone with *Phyllograptus nobilis*, has been established in two localities as mentioned above. At Sandsvær the *bifidus*-fauna is found about 13 m above the Expansus shale (3c β). The occurrence of *Ogygiocaris* near to the base of the shale indicates that the lower portion hardly represents a shaly facies of the Endoceras Limestone (With the possible exception of the *gigas*-beds, since *Ogygiocaris* sp. occurs in the transition beds of Furnes, Nes—Hamar). In the same section the *geminus*-zone is met with about 36 m above 3c β, indicating a considerable thickness of the somewhat arenaceous shale. In the Slemmestad section the Scanian subzone with *Pterograptus elegans* is characteristic.

In the more northern districts the thickness of the shale is practically unknown and the graptolites rarely preserved on account of the tectonics. In judging the presence or absence of the respective zones a careful comparison of the trilobite faunas is also necessary.

At Gausdal NW of the Oslo Region, graptolite shales replace the Orthoceras Limestone (3c) below shales with graptolites indicarting the zones 4a α_{1-2} (Bjørlykke 1905, Lapworth 1905).

Considerable interest is attached to the problem of facies variation in the Upper Didymograptus Shale and the overlying *Ogygiocaris* and *bronni* zones. The facies variation is not restricted to distinct variation in the lithofacies. The differences in closely related faunas, particularly the presence of vicariate forms, suggest important but possibly slight differences in the hydrographical and other conditions.

The presence of two different forms of the index fossil *Ogygiocaris dilatata* is most significant. *O. d.* forma typical (pl. 1) is restricted to the Langesund—Gjerpen and Sandsvær—Eiker districts (with the exception of a specimen from Asker preserved in the Paleontological Museum (Hm)). *O. d. sarsi* (pl. 2) is characteristic of the Oslo—Asker district as well as of Ringerike, Hadeland and the Mjøsa districts.

Ogygiocaris dilatata forma typica occurs in the strata with *Didymograptus bifidus*, and probably appears very early immediately above the transition beds. It is of interest to notice that a related form occurs already in the transitional beds at Furnes (Nes—Hamar). At Sandsvær complete "grave-yards" of *Ogygiocaris* are found at certain levels, but most of the specimens may represent cast exuviae from the moultings.

Not only the two forms of *Ogygiocaris* distinguish the two developments of the Upper Didymograptus Shale and the Ogygiocaris beds. At Sandsvær the index fossil is accompanied mostly by *Asaphus* species, while *Pseudomegalaspis patagiata*, *Trinucleus foveolatus* and others of the Oslo—Mjøsa development, are lacking.

At Sandsvær a mixed graptolite and trilobite facies appears already at the base of 4a α. At Langesund and in the Oslo—Asker district the lower part, 4a α_{1-2}, appears in more typical graptolite facies, containing only small pyritized gastropods and cephalopods besides the graptolites. In the Oslo development the fauna with *Ogygiocaris dilatata sarsi*, *Pseudomegalaspis patagiata* and *Trinucleus foveolatus*, appears fairly late (4a α_3). Its appearance is evidently due to better aeriated conditions and it is possible that these conditions and the associating fauna arrived earlier in the northern districts than in Oslo (Sk).

The fauna mentioned occurs (Oslo—Asker) in shale together with graptolites of the *Glossograptus hincksi* zone (4a α_3). The appearance together with graptolites might perhaps suggest that *Ogygiocaris dilatata sarsi* and its associates were able to endure less ventilated waters than those of the forma typica. Related forms inhabiting adjacent seas are a common phenomenon today. The different species of the recent Xiphosura off the coast of Asia may be mentioned.

Future study of new trinucleids occuring together with the *Ogygiocaris* faunas may permit a closer correlation of the faunas.

The term ''Ogygiocaris Shale'' is not a very fortunate one. Since in the type section of Oslo the typical Ogygiocaris Shale is confined to the layers above the two graptolite zones (4a α_{1-2}), the name is restricted to these layers. In the SW districts, on the other hand, the *Ogygiocaris* fauna also comprises the two lower zones (4a α_{1-2}) and an upper true Ogygiocaris Shale (4a α_3) is consequently difficult to distinguish. (Another complication may be added if the *sarsi*-fauna appears to start earlier at Mjøsa than at Oslo).

In spite of the differences in the faunal elements, the zones 4a α_{1-3} have a fairly uniform development within the Oslo Region. More varied conditions are met with when we pass onwards to the next zone, 4a α_4, which has been termed the *bronni* zone because of the frequent occurrence of *Trinucleus bronni* (= *coscinorhinus*).

In Oslo the *bronni* zone has a number of characteristic sandstone layers. The cross-bedding suggests strong current action, and the prediagenetic slumping of the beds (pl. 3 and fig. 3) may indicate a certain inclination of the bottom (possibly in front of a delta). In two samples investigated, the slumping seems to be directed eastwards, suggesting a transport of material from a western land.

A closer study of these features as well as of the sedimentary petrology, will probably elucidate these problems.

Thanks to graptolite finds (Hm), the age of the *bronni* zone has been fixed to the *Climacograptus putillus*[1] zone, corresponding to the upper part of the *teretiusculus*-zone of Great Britain (fig. 16).

In the *bronni* zone the sandy sediments have apparently a rather local distribution. At Slemmestad (S of Engerodden) the thickness has considerably decreased. At Sandsvær a few m of compact arenaceous beds (fossils not found) are present. (At Eiker a more comprehensive development may be present, but has not yet been studied in detail). In the Langesund—Gjerpen District the *bronni* zone seems to be completely absent. Neither the sandy beds nor the index fossil have been found but the possibility of vicariate species is present. This may suggest a hiatus, probably land conditions during the *bronni*-time. At Ringerike the typical sandy beds are missing. *Trinucleus bronni* is, however, found in the uppermost part of the Ogygiocaris beds below the "conglomerate" marking the base of the Ampyx Limestone (4a β). Probably land conditions existed in this district in the latter part of the *bronni* time. Further N, the characteristic *bronni*-beds seem to be completely lacking. The sandy *bronni*-beds thus appear to have a W—E distribution chiefly comprising the Eiker — Sandsvær, Modum(?), and Oslo — Asker districts.

In Hadeland and in the Mjøsa districts the Ogygiocaris Shale grades into a characteristic thick shale with round limestone nodules, often with barytes. Because of its fauna the shale has been called the Cephalopod Shale. In the Mjøsa districts especially this shale is very fossiliferous and the fauna is almost exclusively confined to cephalopods and gastropods. Only few trilobite specimens are found: *Ogygiocaris dilatata*, *Nileus armadillo*, *Asaphus*, 2 sp. (Holtedahl 1909 p. 9).

Holtedahl (1909 p. 60) was inclined to correlate the Cephalopod Shale with the Ampyx Limestone (4a β). With our present knowledge of the vertical distribution of the tribolites mentioned, it seems more natural, however, to regard the shale as contemporaneous with the *bronni*-zone. This is to a certain extent corroborated by the fact that the uppermost part of the Ogygiocaris Shale in Oslo often contains cephalopod specimens, among them species such as *Lituites lituus* which is characteristic of the Cephalopod Shale.

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[1] The graptolite is now described as *C. haddingi* by Glimberg, (Geol. Fören. Förhandl. Stockholm, *74*, 1952.)

The cephalopod-gastropod facies points to special ecological conditions. The cephalopods were nectonic forms while the gastropods belonged to the benthos. Other benthonic forms such as the trilobites are practically lacking. The gastropods are often preserved in pyrite in the black shale, just as the gastropod specimens are commonly found in the more pronounced black graptolite shale of 4a α_{1-2} in Oslo. The conditions observed may suggest a particular cephalopod sea partly land-locked, with the bottom waters insufficiently aeriated offering living facilities only to gastropods and a few other forms (forms from which fossil remains are not preserved are naturally excepted).

Summing up, we may say that the *bronni* zone, the transition zone between the typical *Ogygiocaris* beds below and the *Ampyx-Reedolithus* beds above, marks a time of local uplifts and erosion (also of Eocambrian or older rocks) causing special ecological conditions in the adjacent seas.

THE CHASMOPS SERIES.

The Ampyx Limestone (*4a* β) *and the Lower Chasmops Shale* (*4b* α).

In the SE districts, comprising primarily Langesund—Gjerpen and Oslo—Asker, the Ampyx Limestone is developed as a comparatively thick zone of nodular limestone with shale. The rather uniform fauna, chiefly characterized by *Reedolithus carinatus*, indicates a fairly short time of deposition. The Ampyx Limestone forms to a certain extent a transgressional zone above the probable hiatus of the S and the coarse beds of the Oslo—Asker District. The transgressional nature is suggested by the basal "conglomerate" of the Ampyx zone of Ringerike. In the SE, calcareous beds prevail suggesting a quiet off-shore (?) sedimentation.

At Sandsvær—Eiker and Ringerike the shale content becomes more significant, indicating increasing accumulation of argillaceous material.

Since determinable graptolites are not known from the zone, the age has to be determined indirectly by the graptolites in the zones below and above. Since the *bronni* zone (4a α_4) corresponds to the *putillus* zone and the graptolites of the overlying Lower Chasmops Shale (4b α) of Oslo indicate the *Diplograptus molestus* zone (= *Clima-*

cograptus peltifer zone), the zone between, the Ampyx Limestone (4a β), probably corresponds to the *Nemagraptus gracilis* zone.

N of Ringerike the *Reedolithus* fauna is not known. In Hadeland and the Mjøsa district the Cephalopod Shale (probably 4a α_4) is succeeded by a thick zone of shale with numerous beds of sandstone. The arenaceous content is particularly conspicuous in the northern districts. The zone, nearly 100 m thick, has very few fossils. Recent graptolite finds in the upper part of the series at Ringsaker indicate a graptolite zone above the one with *Nemagraptus gracilis*. The occurrence of *Pseudomegalaspis patagiata* and *Nileus armadillo* in the lower part of the series suggest that the lower part may correspond to the Ampyx Limestone. A rapid sedimentation is to be assumed for these coarse sediments and it is uncertain whether the whole Ampyx Limestone is present or a hiatus exists somewhere above the Cephalopod Shale.

A distinct differentiation in facies is thus also traceable within the zone of the Ampyx Limestone (4a β). In the SE the calcareous sediments prevail, further NW the shale is more characteristic and in the N a strong conveyance of sandy material, possibly with intervals of emergence, marks the adjacent land.

Somewhat similar local conditions apparently existed during the deposition of the Lower Chasmops Shale (4b α). In the Oslo—Asker District and in Ringerike, the shale contains a rich fauna of brachiopods, cystids, bryozoans and trilobites, a faunal assemblage indicating well aeriated bottom conditions.

Separate graptolite finds point to the zone of *Diplograptus molestus* (= *Climacograptus peltifer*) as mentioned above. In the Langesund—Gjerpen District the beds are more calcareous (have more limestone lenses) and the fauna is mainly characterized by the cystids as emphasized in the name Echinosphaerites Beds.

Northwards, the shale grades into the strongly arenaceous beds of the Hadeland—Mjøsa districts. The beds of the latter districts have been termed the Robergia Beds (Sk) because of the occurrence of *R. microphthalma* together with the graptolites mentioned (the occurrence of *R. m.* at this high level is unexpected).

A differentiation in facies is thus also significant of the Lower Chasmops Shale. In the middle and southern districts, S of the invasion of considerable quantities of sand from rising lands to the N, a vigorous bottom fauna flourished.

The Lower Chasmops Limestone (*4b* β) *and the Upper Chasmops Shale* (*4b* γ) *and contemporaneous deposits.*

The favourable bottom conditions continued through the deposition of the limestone and shale of the Lower Chasmops Limestone. Until the fossils are studied in detail, a strict correlation of the different districts is premature, but generally speaking we may say that the bryozoan beds were contemporaneous with 4b β of Oslo—Asker. Rich fossil faunas are found in the Langesund—Gjerpen, and Sandsvær—Eiker districts, and in the southern part of the Oslo—Asker (Steilene), but in Ringerike and elsewhere in the Oslo—Asker District the fossils are not common. In Hadeland the limestone zone seems to thin out and the zone itself (even in another facies) may possibly be lacking in the N.

In Oslo the Lower Chasmops Limestone (4b β) is succeeded by the Upper Chasmops Shale (4b γ), a characteristic black shale relatively poor in fossils, probably deposited under less ventilated conditions. This black shale facies seems to have a rather local distribution around Oslo. To the SW, W and N this black shale apparently grades into more grey shale and eventually into calcareous sediments.

A certain western and eastern, or rather concentric arrangement of the facies was suggested already by Kiær (1906) for the Silurian and by Holtedahl (1909 fig. 15) for the Ordovician, a view recently elaborated by Skjeseth (1953 b). The concentric arrangement is exaggerated by the strong folding and overthrusting of the sediments in the northern district.

In Ringerike the 4b γ contains a trilobite and lamellibranch fauna representing a transition between the black shale of Oslo and the largely contemporaneous algal and branchiopod assemblages of the facies to the SW and N. The characteristic algal (*Mastopora, Coelosphaeridium* and *Cyclocrinus*) (pl. 4) and brachiopod limestones and shales are confined to a western arc (not continous) comprising the districts of Langesund, Gjerpen and Sandsvær in SW, and N. Hadeland and the Mjøsa districts in the N. The sediments were evidently deposited in quite shallow littoral waters. Breaks might be present. As mentioned in unprinted notes by Kiær, the frequent occurrence of *Coelosphaeridium* sp. not far below the base of the Encrinite Limestone in the Langesund—Gjerpen District, may imply the absence of the *Cyclocrinus* beds in the southern district.

Passing from S to N the invasion of sandy material is already significant in N Hadeland, but becomes very typical in the *Cyclocrinus* beds of the Mjøsa districts.

Summing up the condition during the deposition of the Lower Chasmops Limestone (4b β) and the Upper Chasmops Shale (4b γ) the following features are salient. In this period, also, a land to the N or NW is suggestive, consisting of Eocambrian or older rocks being subject to considerable erosion, producing great amounts of sand. (A western "Telemark Land", such as emphasized by Skjeseth (1952) for the time of the Lower Didymograptus Shale (3b), is suggested in the thick, partly arenaceous Upper Didymograptus Shale (4a α_{1-2}) of Sandsvær). The algal-brachiopod facies, forming a western arc, were probably deposited along a coast, possibly of smaller islands. In the N great quantities of sand (from Eocambrian or older rocks) were transported from a main land, probably by a main river system, and deposited on the bottom of the shallow waters along the coast. In the S arenaceous material is less common. Local uplifts during the *Cyclocrinus* time, probably furnished calcareous and argillaceous material only. Towards the inner, eastern arc, the deposits suggest more stagnant waters immediately above a probably rather foul bottom. This distribution of the sediments lagely corresponds to that assumed by Skjeseth (1952) for the zone-complex 3b.

The Upper Chasmops Limestone (4b δ) and contemporaneous deposits.

The prominent limestones terminating the Middle Ordovician sections of the Oslo Region are most conspicuous. The facies of the limestones differs within the same arcs as was suggested for the zones below. The fossil floras and faunas differ to such a degree that a detailed correlation may be difficult or even impossible between remote districts.

Starting with the western arc, comprising Langesund—Gjerpen, Sandsvær and the Mjøsa districts, we find the zone developed as a mostly compact limestone ranging in thickness from about 40—100 m. The underlying shale and limestone of the S, and the shale and arenaceous beds of the N., rapidly, but still gradually, change into the overlying limestone, the Encrinite Limestone of the S, and the Mjøsa Limestone of the N. The sand, so conspicuous in the *Cyclocrinus* beds of the N, now decreases and disappears, indicating the cessation of the supply of sand carried from the adjacent land.

Characteristic of the limestone of the western arc is the abundance of calcareous algae (*Solenopora*), crinoids (stems), corals and stromatoporids. Regular coral- and stromatoporid reefs occur in places, and brachiopod — bryozoan — trilobite faunas may alternate with the assemblages mentioned.

The corals (Hill 1952) of the S and N do not belong to the same species, but the presence of the same genera indicates a fairly common age of the two limestones. With our present, preliminary knowledge of the fossils, it is very probably that the Encrinite and Mjøsa Limestones are more or less synchronous. Since the Mjøsa Limestone is not succeeded by the Lower Tretaspis Shale, but by a Silurian quartzite, marking a considerable hiatus below, it is possible that the Mjøsa Limestone lasted longer than the limestone of the S. Future detailed studies of the fossils will furnish better material for a more accurate correlation.

The limestones with their algae and corals were evidently deposited in shallow water. At Langesund ripple-marks and mudcracks have been observed, and at Mjøsa deeper erosion furrows occur. Frequent local emergences, some of them more important than others, apparently took place during the deposition. Cross-bedding, partly on a large scale (fig. 10), suggests strong currents or wave action.

A next arc is suggested by the Sphaeronid Limestone of Hadeland N. This thick limestone appears as a nodular limestone, not a compact limestone as in the outer western arc. Calcareous algae are present to a certain extent, and a few rugose corals too, but otherwise the fossils comprise cystids, brachiopods and trilobites. Of particular interest is the overlying Gagnum shale, a fairly dark shale with limestone bands containing a trilobite-brachiopod fauna (Størmer 1945, p. 387). The presence of *Tretaspis ceriodes* and *T. kiæri* shows that this shale also belongs to the zone of the Upper Chasmops Limestone (4b δ_1-$_2$). *T. ceriodes* is also characteristic of the Sphaeronid Limestone which evidently corresponds to the main part of 4b δ.

At Ringerike cystids are also characteristic of parts of the Upper Chasmops Limestone which otherwise has much in common with the limestones of S Hadeland and Oslo—Asker, thus representing an eastern inner arc. In these districts the nodular limestone is more or less replaced by continuous limestone beds alternating with dark shale suggesting less fresh bottom conditions. In the faunas the trilobites prevail.

In Oslo the uppermost beds of the 4b δ are developed as a black shale with a few large lenses containing *Tretaspis ceriodes angelini.* Above this there comes a layer of phosphatic nodules indicating a hiatus. Further W in Asker and NW in Ringerike higher beds of the 4b δ evidently appear. The upper zone with *Tretaspis kiæri* (4b δ_2) is preserved in Ringerike and Hadeland, and the transition upwards into beds with the first *T. seticornis* shows no marked sign of breaks. Lithologically a hiatus would be more likely in the sandy basal beds of the black Tretaspis Shale (4c α). In Oslo a hiatus above the Upper Chasmops Limestone is very Probable, but a similar pronounced break seems hardly to be present at Ringerike.

The Gagnum Shale of N Hadeland is succeeded by the Gagnum Limestone which probably forms a limestone facies of the Lower Tretaspis Shale (Størmer 1944). It does not seem necessary to assume a major hiatus here. The hiatus may possibly occur higher up between the Gagnum Limestone and the Gastropod Limestone (4c—5a). Further N a large hiatus appears between the Mjøsa Limestone and the Lower Silurian, leaving out the complete Upper Ordovician and probably parts of the basal Silurian.

If we try to visualize the general conditions during the deposition of the Upper Chasmops Limestone time, we have to bear in mind that in the western arc, both in this and the zones below, a distinct relation to the corresponding Baltic faunas is significant (pointed out by Brøgger and others). This indicates an undoubted connection through a common sea, or through common coastal waters rather, between the two remote regions. While the Oslo Region occurrences were probably situated not far from the SE borders of the Caledonian miogeosyncline, the Baltic ones were situated on the craton far from the borders of the miogeosyncline. The algal and coral reefs probably grew along the shores of festoons of low islands sometime sheltering les well aeriated waters behind them, waters supporting a bottom fauna chiefly composed of trilobites (besides non-preservable forms).

During the subsequent time, the barrier increased considerably as indicated by the prominent hiatus in the Mjøsa districts. This barrier may have been one of the major reasons for the formations of the typical black shales of the Lower Tretaspis Shale. The large areas of black shale, both in Norway and Sweden, suggest a great sea with badly ventilated bottom, a sea sheltered to the NW and W by the barrier mentioned.

A review of the Middle Ordovician sediments of the Oslo Region shows the following main feature: the constant alternation between limestone and dark shales, a struggle between fresh bottom deposits and black mud sedimented under less well aeriated conditions. The ecological changes are also influenced by occasional emergences of land, both in the sedimentary region where the uplift resulted in supplies of clay and calcareous mud, and in the regions outside the ''Oslo Region'' where the rising land of Eocambrian and older rocks resulted in considerable supplies of sand.

A preliminary correlation chiefly with the Swedish and Baltic sections.

In fig. 16 the Oslo—Asker section is correlated with the British graptolite zones. The nomenclature of the series has varied somewhat from time to time. Dr. C. J. Stubblefield has kindly informed me about the designations now used by the Geological Survey of Great Britain. According to their terminology the Llanvirn comprises both the *bifidus* and *murchisoni* zones, while the Llandeilo is confined to the *teretiusculus* zone only. The zone of *Nemagraptus gracilis* is included in the Caradoc since the guide fossil occurs in the basal part of this Series (Stubblefield 1930 p. 87, Williams 1951 p. 5). The Caradoc thus includes the *gracilis*, *peltifer*, *wilsoni*, *clingani* and *linearis* zones.

This division is apparently not unanimously adopted. (Jones 1938) is inclined to have the lower boundary of the Caradoc within the *gracilis*-zone. On the other hand he has used the Llandeilian to embrace the *teretiusculus-peltifer* zones, just like Elles and Wood (1901). Caradoc—Ashgill is sometimes called Lower and Upper Bala.

Sweden. The main features in the correlation of the Middle Ordovician series of Scandinavia are fairly well-known. One may distinguish an Asaphus Series (upper part), succeeded by a Chasmops Series. The name Ogygiocaris Series is here suggested for the upper part of the Asaphus Series.

The graptolite shale-facies prevail in Scania in the S and also to some extent in the allochthone of Jämtland further N. In Central Sweden and the autochthone of Jämtland, on the other hand, limestones with shelly facies are common, particularly in the lower part

GRAPTOLITE FACIES					TRILOBITE-GRAPTOLITE FACIES				
BRITISH ISLES			SWEDEN Scania		OSLO REGION Oslo-Asker – Ringerike				
	Zone of:		Zone of:		Zone of:				
Caradoc	*Pleurograptus linearis*		*"Pleurograptus linearis"*		$4c\alpha$	*Tretaspis seticornis*	=	Lower Tretaspis Shale	Tretaspis series→
	Dicranograptus clingani		*Dicranograptus clingani*		$4b\delta_2$	*Tretaspis kiaeri*		Upper Chasmops Limest.	Chasmops series
					$4b\delta_1$	*Tr. ceriodes* *Ch. extensa*			
	Climacograptus wilsoni		*Amplexograptus vasae*		$4b\gamma$	*Cryptolithus discors*	=	Upper Chasmops Shale	
					$4b\beta$		=	Lower Chasmops Limest.	
	Climacograptus peltifer		*Diplogr. molestus* = *(Amplex. rugosus)*		$4b\alpha$	*Chasmops conicophthalma*	=	Lower Chasmops Shale	
	Nemagraptus gracilis		*"Nemagraptus gracilis"*		$4a\beta$	*Reedolithus carinatus*	=	Ampyx Limestone	
Llandeilo	*Glyptograptus teretiusculus*		*"Climacogr. putillus"*		$4a\alpha_4$	*Trinucleus bronni*	=	Bronni Beds	Ogygiocaris series
			Glossogr. hincksi – *Diplogr. linnarss*		$4a\alpha_3$	*Trinucleus foveolatus*	=	Ogygiocaris Shale	
Llanvirn	*Didymograptus murchisoni*		*Didymogr. clavulus* *Pterogr. elegans*	*Pterogr. sanicus* *Phyllogr. glossogn*	$4a\alpha_2$	*Didymogr. geminus*		Upper Didymogr. shale	
	Didymograptus bifidus		*Didym. bifidus*	*Azygogr. falciform.* *Phyllogr. nobilis*	$4a\alpha_1$	*Didymogr. bifidus*			
Arenig	*Didymograptus hirundo*		*(Megalaspis limbata)*		$3c\gamma$	*Megalaspis gigas* *Megalaspis grandis*		Endoceras limest.	Asaphus series
					$3c\beta$	*Asaphus expansus*		Asaphus shale	
					$3c\alpha$	*Megalaspis limbata*		Megalaspis Limest.	
			Isograptus gibberulus		$3b\varepsilon$	*Didym. hirundo*		Lower Didymogr. shale	
	Zone-complex of: *Didym. extensus*	*Isograpt. gibberulus*			$3b\delta$	*Phyllograptus angustifolius elongatus*			
		Didym. nitidus	*Phyllograptus densus*		$3b\gamma$	*Phyllograptus densus*			
		Didym. deflexus	*Didymograptus balticus*		$3b\beta$	*Didymograpt. balticus*			
		Tetragr.	*Tetragraptus phyllograptoides*		$3b\alpha$	*Tetragraptus phyllograptoides*			

Fig. 16. A correlation of graptolite- and trilobite zones.

of the series. The series of the Oslo Region have much in common with the allochthone of Jämtland, but occupies at the same time a somewhat intermediate position between the shale and limestone facies of Sweden.

Starting with the basal part of the section, the *bifidus* zone (Ekström 1937 p. 49) succeeds the zone of *Megalaspis limbata* in Scania. Since the latter zone evidently corresponds to 3c α—3c β of the Oslo Region a hiatus comprising the Endoceras Limestone 3c γ (including at least parts of the Gigas Limestone) which correspond largely to the Vaginatum Limestone of Sweden (Jaanusson and Mutvei 1951, p. 635), must be present.

The subzone with *Megalaspis grandis* (= *centaurus*) is characteristic also of Sweden, underlying the Gigas Limestone of Öland (Bohlin 1949). The Vaginatum Limestone of Dalarna has quite recently been studied by Jaanusson and Mutvei (1951 p. 630). *Cyclendoceras vaginatum* continues upwards into the Gigas Limestone.

The Gigas Limestone is succeeded by the Platyurus Limestone which may be more or less equivalent to the *bifidus* zone. Above the Platyurus Limestone there comes the Schroeteri Limestone, previously called the Centaurus- or Chiron Limestone (Westergård 1943 p. 75). According to Moberg (1890 p. 16), this limestone on Öland contains, besides *Illaenus schroeteri* (= *I. chiron*), among others *Ogygiocaris dilatata sarsi, Pseudomegalaspis patagiata, Telephus bicuspis* suggesting the zone of 4a α_3 or possibly 4a α_4 of the Oslo Region. Thorslund (1940 p. 121) is inclined to regard the Schroeteri Limestone as equivalent to the *Climacograptus putillus* zone ≐ 4a α_4.

The Ancistroceras Limestone succeeding the Schroeteri Limestone on Öland may be regarded as a subzone of the latter (Westergård 1943 p. 75).

The development of the beds corresponding to the zones of *Climacograptus putillus* and *Nemagraptus gracilis* is of particular interest. In Dalarna Jaanusson (1947 p. 46) regards the so-called "Flag Limestone" as a separate zone with the guide-fossils: *Illaenus crassicauda* and *Tallinnella dimorpha*. Because of the occurrence of *Lasiograptus* (*Hallograptus*) *bimucronatus* the zone has been correlated with the *gracilis*-zone. The Crassicauda Limestone deviates from the underlying Schroeteri Limestone in having species of *Chasmops* and no *Pseudomegalaspis patagiata*. There is reason to believe that the Crassicauda Limestone may be correlated with the Ampyx Limestone (4a β) of Oslo.

In Jämtland the *gracilis* zone of the autochthone is evidently represented by a basal conglomerate and sandstone (Loftarstone) and otherwise missing (Thorslund 1940 p. 121).

Both in Scania and in the allochthone of Jämtland, the *putillus* and *gracilis* zones appear in shaly, mostly graptolite facies. Since trilobites also occur to some extent, a more accurate correlation with the Oslo Region might be attempted.

In the Oslo Region the *putillus* zone is probably represented by the *bronni* zone (4a α_4) which has a very variable development suggesting unstable conditions with local uplifts and the erosion of adjacent regions.

The *bronni* beds also occur in Scania (Funkquist 1919 p. 22 and Nilsson 1951) where it rests on beds of variable ages (Asaphus Limestone to *geminus* zone?) thus forming an overlapping zone. This is also suggested by the presence of a conglomerate and a phosphatic bed as well as by an increase of mica in the shale (Hede 1951 p. 63). Similar conditions are found on Bornholm (Poulsen 1936 p. 51).

In the allochthone of Jämtland arenaceous beds occur in the Upper Ogygiocaris Shale (Hadding 1929 p. 173, Thorslund 1940 p. 106, 121).

When comparing the *bronni* beds of Sweden and Norway it is important to establish the accurate age of these beds. Nilsson (1951 p. 687) discusses the age of the *bronni* beds in Scania. Just below the beds (above the conglomerate) there occurs a graptolite fauna including *Dicranograptus irregularis* which is elsewhere found in the *putillus* zone. The overlying mudstone carries *Trinucleus bronni*, *Telephus granulatus* and *Nileus armadillo*.

In determining the age of the *bronni* beds, Nilsson points to the presence of the guide-fossil in a zone above the zone of *Ogygiocaris dilatata* in Norway (Størmer 1930 p. 74). As shown above, however, *Trinucleus bronni* is characteristic of a zone (4a α_4) above the typical Ogygiocaris Shale (4a α_3), but the species *Ogygiocaris dilatata* still occurs in the *bronni* zone. The occurrence of *Telephus granulatus* in the upper part of the Ogygiocaris Shale of Jämtland, a shale determined as belonging to the *gracilis* zone by Hadding (1912 p. 601) is also mentioned in favour of the higher zone. In Norway, however.

T. granulatus occurs in the typical Ogygiocaris Shale (4a α_3) (Sk) apparently belonging to the *hincksi* zone below the *putillus* zone.

The Ogygiocaris Shale of the allochthone of Jämtland, which includes the arenaceous beds above mentioned, evidently extends further upwards comprising the *putillus* zone and possibly the lower part of the *gracilis* zone as suggested by the presence of *Ogygiocaris dilatata sarsi* in the lower part of the *gracilis* zone which is represented here by *Nemagraptus gracilis remotus* (Hadding 1913 p. 24).

Although the Ogygiocaris Shale of the Jämtland allochthone may possibly extend upwards into the *gracilis* zone, it seems natural to correlate the *bronni* beds of Scania with the very similar *bronni* zone of Oslo (4a α_4), the zone above the typical Ogygiocaris Shale (4a α_3) of this region, and apparently contemporaneous with the *putillus* zone. Whether the arenaceous beds of Jämtland are of the same age or slightly younger, is still uncertain.

In all events the sections of the Oslo Region and Sweden indicate a period of considerable unrest just before the deposition of the zone of Nemagraptus gracilis.

As pointed out by Thorslund (1940 p. 121) and Størmer (1945 p. 396) the base of the *gracilis* zone forms a natural base of the Chasmops Series in Scandinavia. Nilsson (1951 p. 692, 693) is of the same opinion but is also inclined to include the *bronni*-zone which in my opinion belongs rather to the unstable period terminating the typical Ogygiocaris beds.

The emergence before the deposition of the *Nemagraptus gracilis* zone seems to have had a wide distribution and may have been a general feature. The Crassicauda Limestone, evidently corresponding to this zone, is missing both in the autochthone of Jämtland (Thorslund 1940) and in the core of Gotland (Thorslund 1938). As suggested by Thorslund (1940 p. 183) the Benan Conglomerate of Girvan, Great Britain, and the Rysedorph Hill Conglomerate of U.S.A. may possibly be more or less contemporaneous. It might be mentioned that in the Llandeilo District of Wales, Great Britain, the Llandeilo Flags are followed, with profound lithological and faunal change by the *gracilis* shales (Williams 1951 p. 5).

Our knowledge of the Chasmops Series of Sweden is recently increased by field studies in Jämtland (Thorslund 1940) and Dalarna (Thorslund 1935, Jaanusson 1947, and Jaanusson and Martna 1948), and through borings on Gotland (Thorslund and Westergård 1938) and at Kinnekulle, Västergötland (Thorslund 1948).

In the allochthone of Jämtland the sections have much in common with those of the Oslo Region. The Schroeteri Limestone is thus developed as a shale (= 4a α_3) and in the overlying Chasmops Series dark bedded limestone and black shale prevail (Thorslund 1940 p. 95). The lower part of the series contains *Asaphus ludibundus*, *Echinosphaerites aurantium* a.o., the upper *Tretaspis ceriodes* (l.c. p. 125). *T. ceriodes* also occurs at the base of the Masur Limestone which probably forms a transitional zone between the Chasmops and Tretaspis Series as mentioned by Thorslund. Immediately below the Masur Limestone the shale contains *Dicranograptus clingani*, and a little further down, *Amplexograptus vasae.*

In the autochthone of Jämtland, in Dalarna, and elsewhere in southern Sweden except in Scania, limestone beds predominate in the Chasmops Series. In Jämtland the lower part (about 20 m) contains *Chasmops conicophthalma*, *Asaphus lubibundus* a.o., the upper part (10—15 m) *Chasmops extensa*, *Tretaspis ceriodes*, *Cryptolithus discors* a.o. The species show the connection with the Oslo Region. *C. discors* is associated with *Amplexograptus* cf. *vasae*. Since *C. discors* has appeared to be characteristic of 4b γ at Oslo, the occurrence in Jämtland suggests the zone 4b γ to be equivalent to the *vasae* zone and consequently the 4b δ to be equivalent to the *clingani*-zone (*Tretaspis ceriodes*).

The lowest part of the Chasmops Series in Dalarna is represented by the Crassicauda Limestone, as mentioned above. The corresponding zone is evidently missing in the Jämtland authochthon (Jaanusson 1947). The Lower Chasmops Limestone with *Asaphus ludibundus* contains beds of plastic clay (parabentonite). The Upper Chasmops Limestone (Macrourus Limestone and Shale) has *Chasmops macrourus* which may be identical with *C. extensa*. The limestone passes into the Slandrom Limestone (= Masur Limestone) in the upper part of which occurs *Tretaspis seticornis*, thus confirming the assumption of the Slandrom Limestone forming a transition between the Chasmops- and Tretaspis Series (Jaanusson and Martna 1948). The conditions seem to be similar to those in Ringerike and Hadeland where bedded limestone and shale form the transition.

The upper part of the Chasmops Series is locally developed as reef-limestone, the Kullsberg Limestone (Thorslund 1935) which seems to extend onwards into the Tretaspis Series. The reef limestone which also appears to be present in the northern Baltic, may be compared, at least the lower part, with the Mjøsa Limestone of the Oslo Region (Størmer 1945 p. 397).

In the deep borings at Kinnekulle, Västergötland (Thorslund 1948), the Chasmops Series has a thickness of 28—30 m of which only the uppermost 2—3 m belong to the Upper Chasmops beds. Characteristic of the series are the thick layers of plastic clay (parabentonite). As in sections of the Oslo—Asker District, *Tretaspis ceriodes* occurs at the top of an Upper Chasmops limestone (= 4b δ) below the black Tretaspis Shale (= 4c α). The occurrence of *Dicranograptus clingani* and *Amplexograptus vasae* in the shale just below is of importance. The mixture of these guide fossils in the same beds shows that one has to be cautious in determining the zone of the shale. In this connection it may be mentioned that Nilsson (1951 p. 691, foot-note) has found *Nemagraptus gracilis* together with *Amplexograptus rugosus*, two species which also are guide-fossils of succeeding graptolite zones.

A considerable break is probably present between the Upper and Lower Chasmops beds (the break may possibly be somewhat lower than at 65.75 m since *Philipsinella* cf. *parabola* extends a little further down). The occurrence of *Reedolithus carinatus* above *Amplexograptus rugosus* (= *Diplograptus molestus*) is of interest.[1] This may suggest that the 4a β of the Oslo Region extends into the *rugosus* (or *molestus*-) zone (if *R. carinatus* has the same range in Sweden, and if the graptolite does not extend below its zone). A comparison with the sequence of the Oslo Region suggests that a major part both of the Lower and Upper Chasmops Series is absent at Kinnekulle.

The boring on Gotland (Thorslund and Westergård 1938) suggests a break just above the Macrourus Limestone.

Summing up, we may say that the Chasmops Series of Sweden comprises the same interval as in Norway, from the base of the *gracilis* to the top of the *clingani* zone. Both below and above the series breaks occur in a number of localities. The Swedish sequences appear to be less complete, a feature also suggested by the lesser thickness of the zones.

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[1] Dr. Bulman has verbally indicated that the species described as *Diplograptus molestens* by Thorslund (1948) may not be indentical with *Amplexograptus rugosus* Hadding (1915) non Tullberg.

The Baltics. Boulders from the Northern-Baltic Region (Wiman 1906) suggest a section related to that of Mjøsa ("Baltic Sea" Limestone).

Brøgger (1884, 1887) already tried to correlate the Middle Ordovician of the Oslo Region with that of Esthonia. He correlated 4b α—β with Kuckers (Kukruse) — Itfer (Idavere), the *Mastopora* beds of Langesund with the Jewe (Jöhvi), and the Encrinite Limestone (4b δ +) with the Kegel (Keila). Holtedahl (1909) correctly regarded the *Coelosphaeridium* beds of Mjøsa as contemporaneous with the Jewe (Jöhvi), but the younger beds were placed too high on account of an earlier erroneous determination of the age of the Mjøsa Limestone. Raymond (1916) correlated the *Coelosphaeridium* and *Cyclocrinus* beds with the Jewe (Jöhvi) and Kegel (Keila) with which they undoubtably have very much in common. The overlying Mjøsa Limestone and the Upper Chasmops Limestone (4b δ) should then be equal to the upper part of the Kegel (Keila) or the Wesenberg (Vasalemma), or both.

The correspondance in the late Middle Ordovician algal floras of the "western" facies of the Oslo Region, the North Baltic and Esthonia, suggests more or less continuous littoral conditions.

The lower boundary of the Chasmops Series of the Oslo Region probably corresponds to the base of the Crassicauda Limestone of Dalarna which Jaanusson (1947 p. 48) correlates with the base of the Uhaku stage ($C_1\delta$). In the Baltic countries, however, the *Chasmops* species appear earlier than in Scandinavia and a lower boundary of the Chasmops Series is therefore less pronounced in the fauna.

Other countries. Correlations with other countries are postponed till more complete fossil lists have been obtained. It may be mentioned that the characteristic *Tretaspis kiæri* of Ringerike is apparently a guide fossil in England (Bancroft 1933) and also occurs in Belgium (Richter, R.a. E. 1951). *Tretaspis clarkey* from Newfoundland (Cooper 1930 p. 288) seems to be identical with *T. ceriodes* and the fauna is also otherwise similar to our 4b δ.

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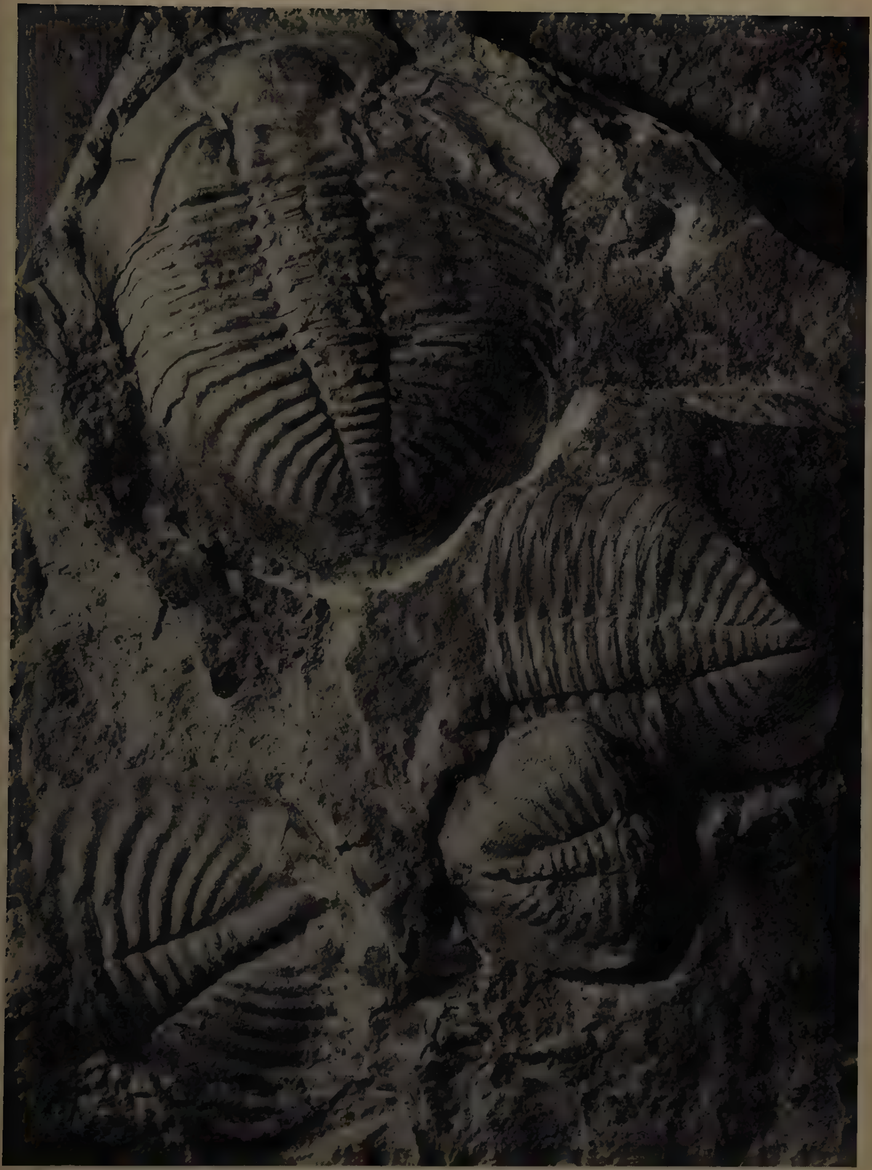
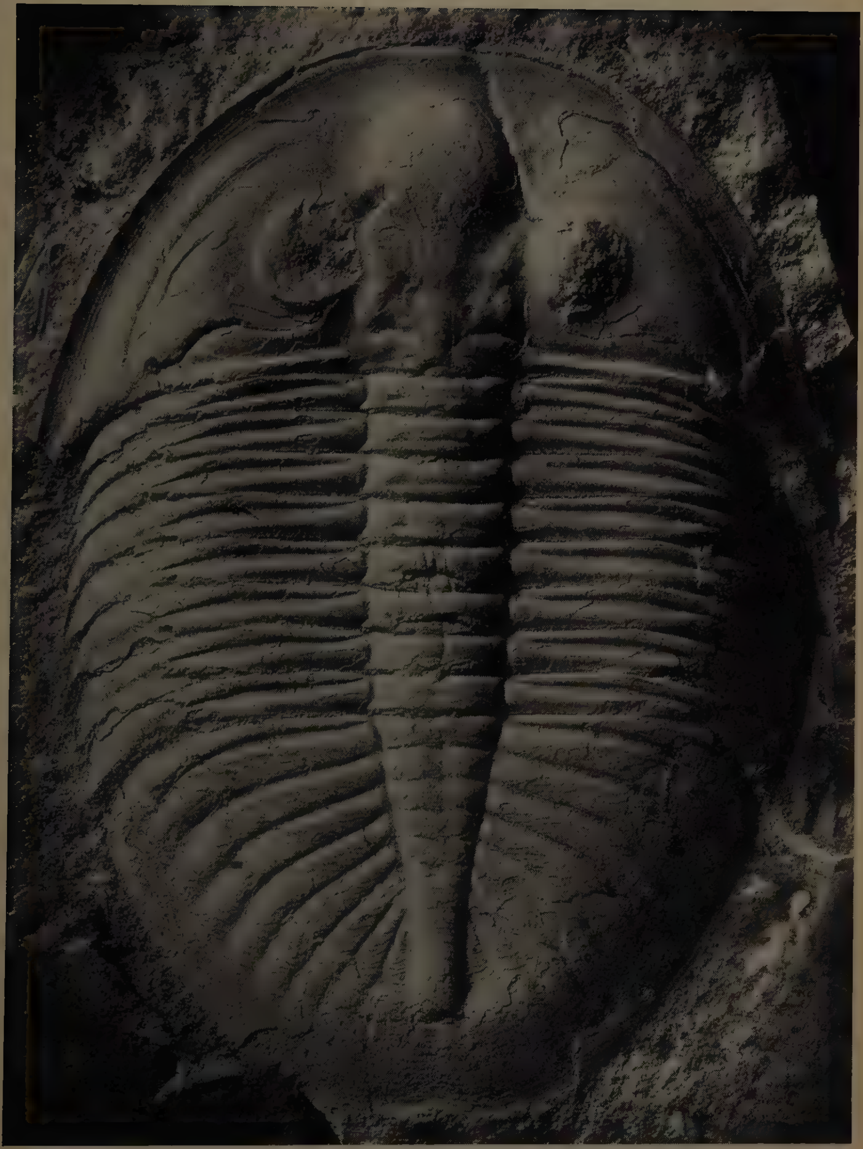
PLATES

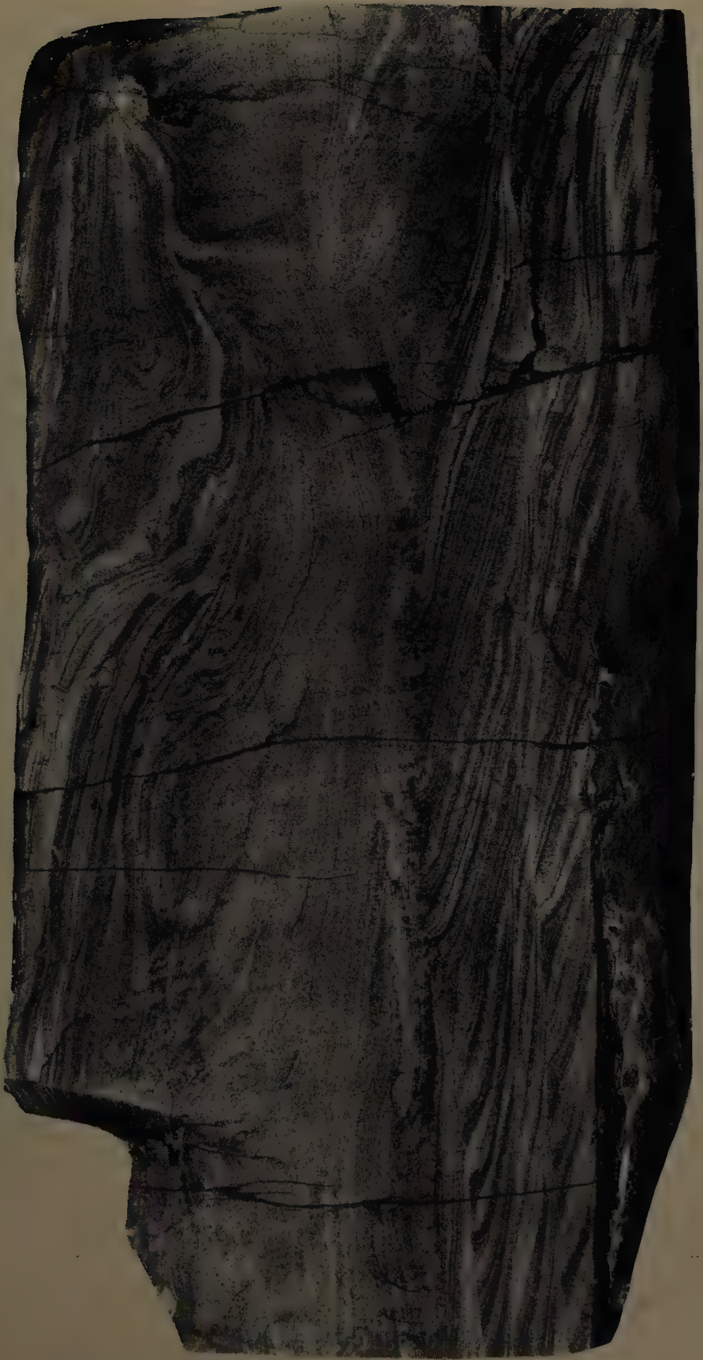
Photographs not retouched. Specimens belong to the Paleontological Museum of the University in Oslo. Photographs by Miss B. Mauritz.



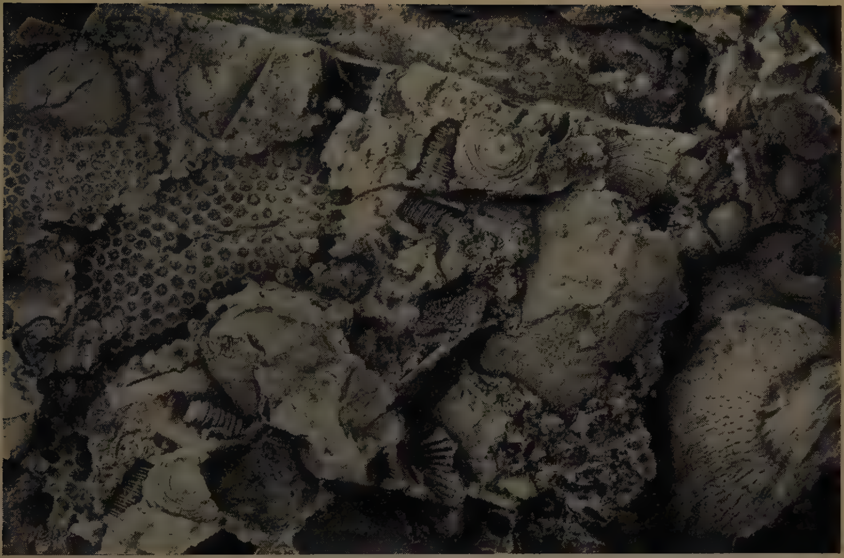
Pl. 1. Ogygiocaris dilatata, forma typica. 0.6 ×. Ogygiocaris beds, 4a α_3, Muggerudkleiva, Sandsvær. L. and P. Størmer coll.

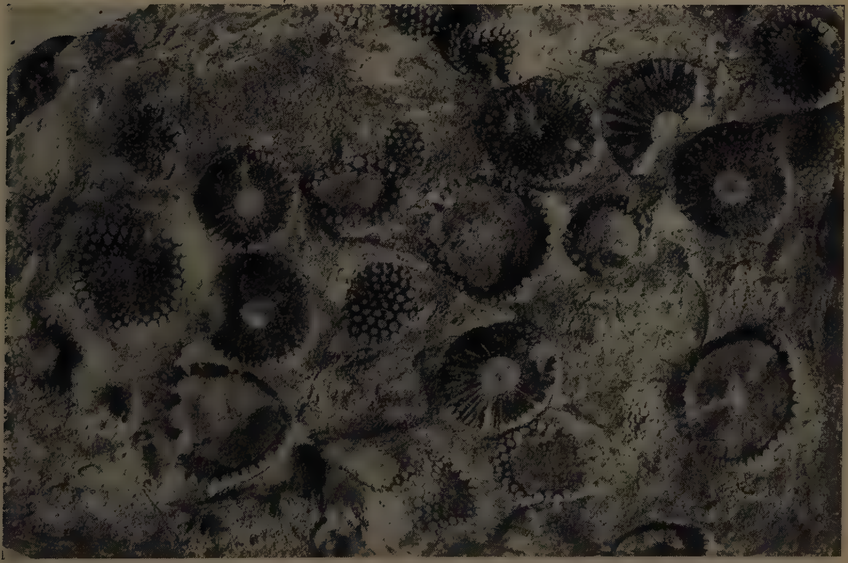


Pl. 2. Ogygiocaris dilatata sarsi. 1.4 ×. Probably Ogygiocaris beds, 4a α_3. Toten. Old collection.



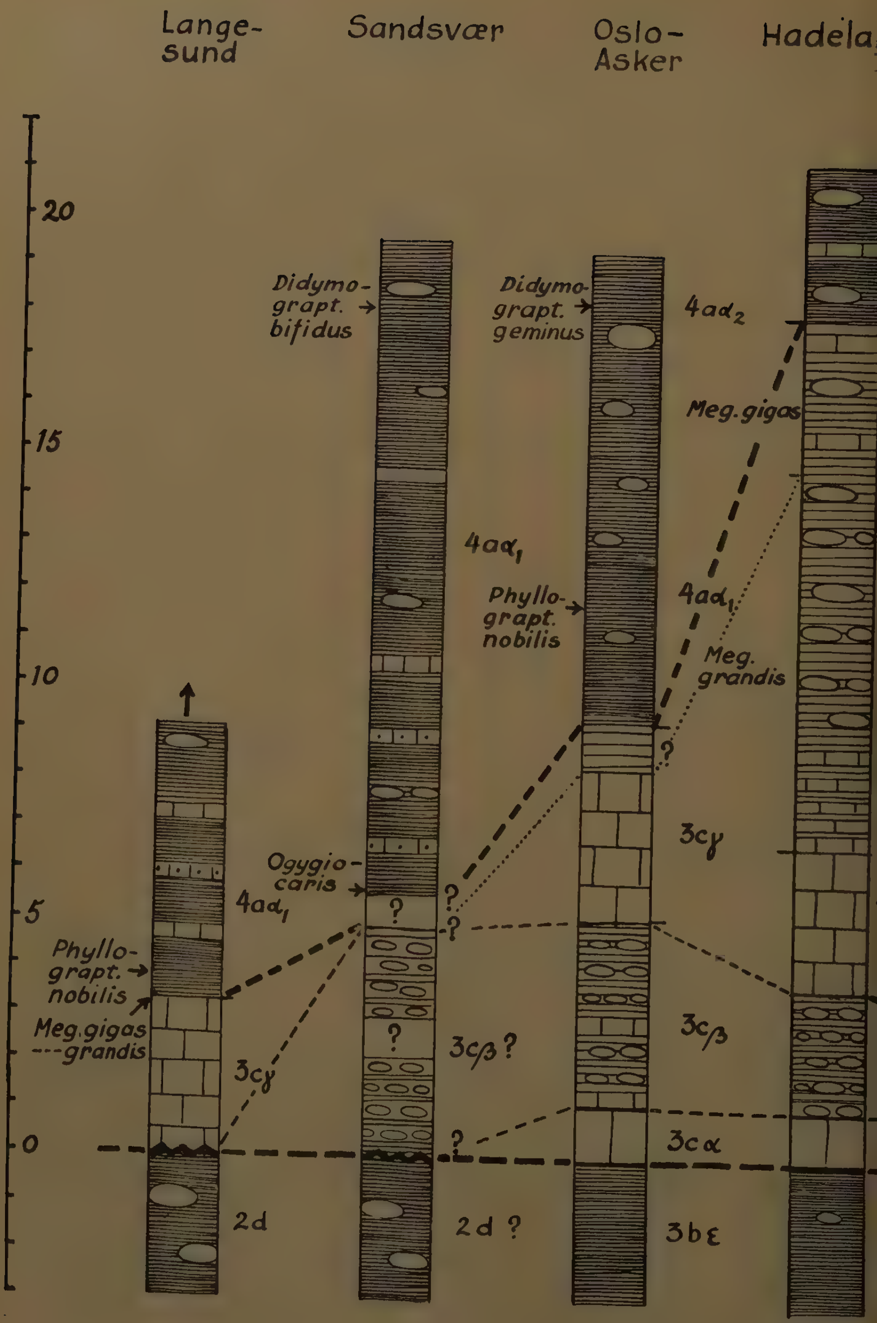
Pl. 3. Arenaceous beds of the Trinucleus bronni zone (4a α_4) on the island Killingen, near Oslo. In the lower part (to the right) normal crossbedding. In the upper part the beds are disturbed by slumping. Slightly reduced. Photographed in distilled water. Aut. coll.



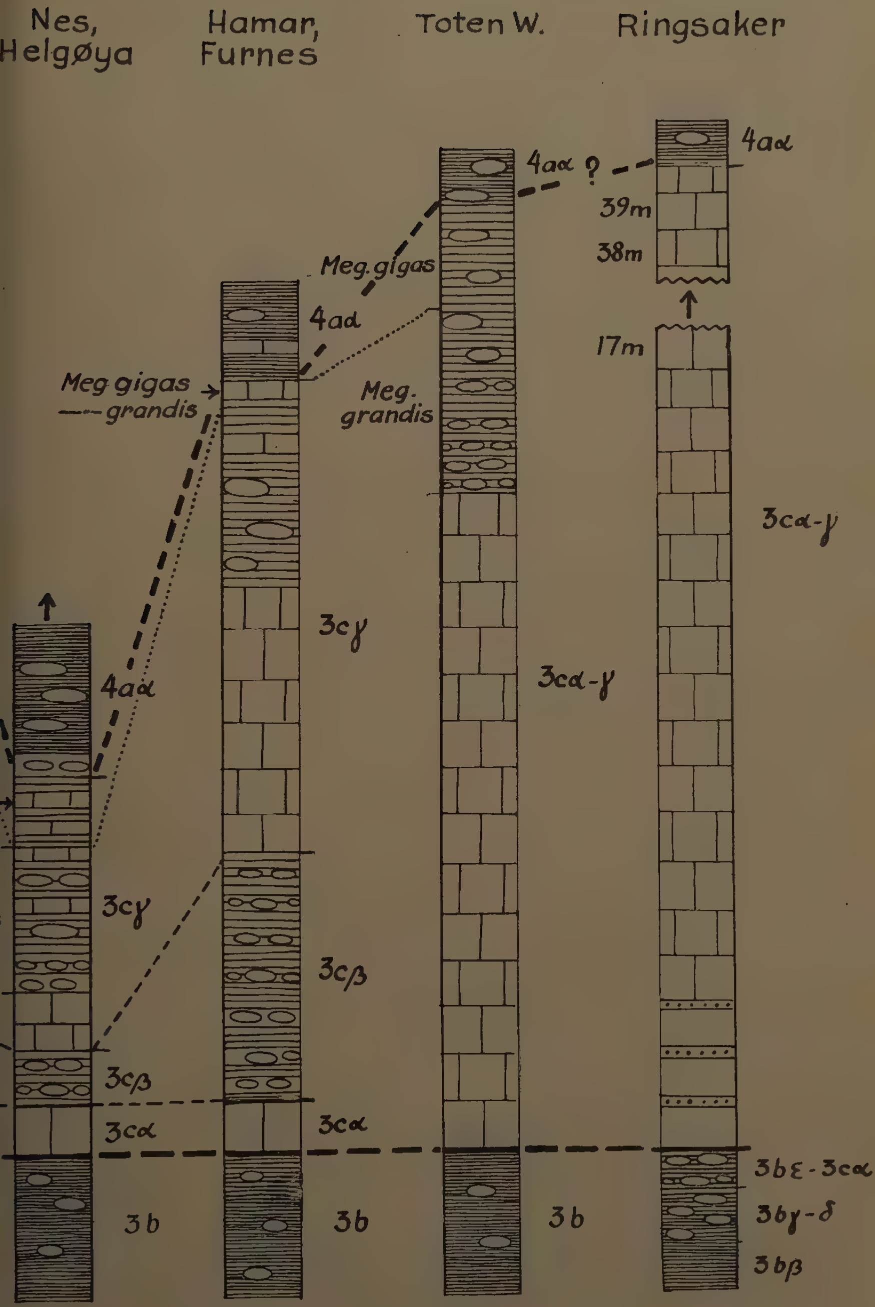


Pl. 4. Fig. 1. Fossiliferous Coelosphaeridium beds of Törud-Brattberg, Ringsaker. To the left *Mastopora concava*. Specimen whitened. Skjeseth coll. About 1 ×.

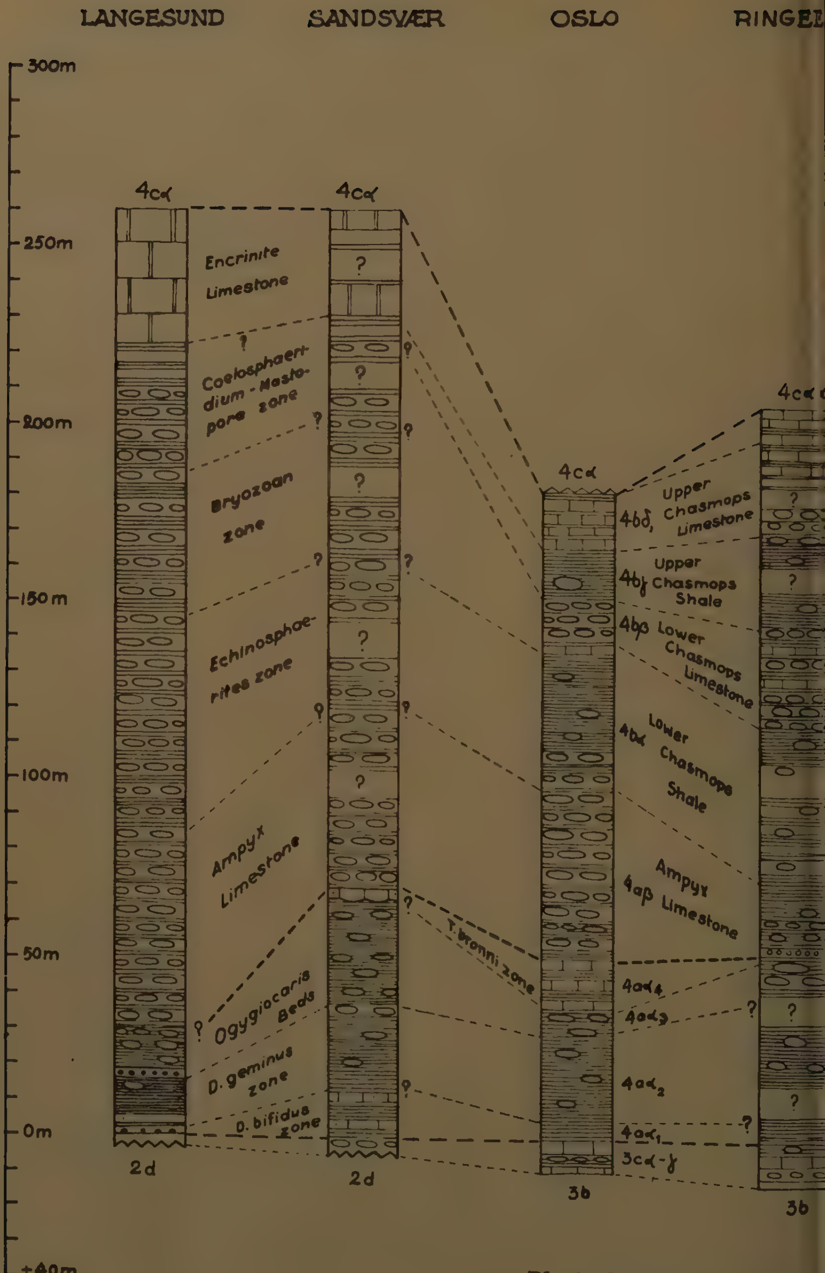
Fig. 2. *Coelosphaeridium* sp. 1 ×. Coelosphaeridium zone at Veldre. Polished surface.



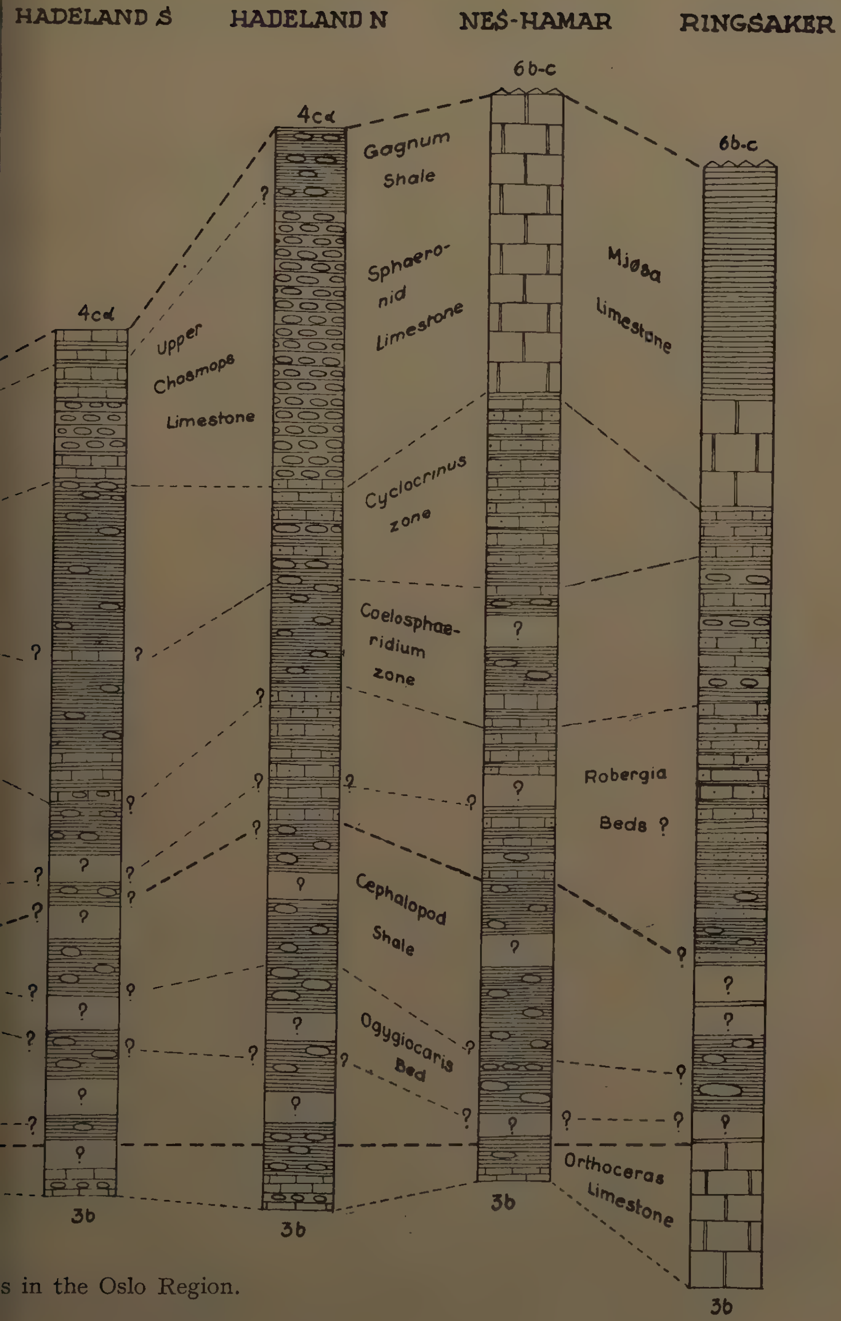
Pl. 5. Lower Middle Ordov



ssions in the Oslo Region.



Pl. 6. Middle Ordovician



s in the Oslo Region.

THE MIDDLE ORDOVICIAN OF THE OSLO REGION, NORWAY

2. Some Rugose and Tabulate Corals.

BY

DOROTHY HILL,
University of Queensland, Brisbane.

(With five plates.)

Abstract. Five new species of Rugosa and four of Tabulata are described with two others previously known. They are from the Cyclocrinus Beds of the region north of Oslo, from the overlying Sphaeronid (Chasmops) and Mjøsa Limestone of the same region and from the Encrinite Limestone in the Gjerpen—Langesund district. All are Middle Ordovician in character, and indicate an age within the limits *Climacograptus peltifer* and *Dicranograptus clingani* zones of the standard graptolite sequence.

Introduction.

The small collection of corals described in this paper is derived from the Hadeland, Toten, and Mjøsa districts to the north of Oslo, and from the Gjerpen—Langsund district to the southwest of Oslo, and is housed in the Palaeontological Museum, Oslo. It was made available to me through the courtesy of Professor, dr. Leif Størmer and curator, cand. real. Gunnar Henningsmoen.

The corals are all Middle Ordovician, and so form a contribution to the stock of knowledge necessary before we can understand the origin and interrelations of the great families of Rugosa and Tabulata.

The formations yielding the corals are the Cyclocrinus and Mastopora Beds of the northern region, the overlying Sphaeronid (Chasmops) or Mjøsa Limestone of the northern region, and the Encrinite Limestone of the Gjerpen—Langesund district. Recent work in Scandinavia (Størmer, 1945) supports Kiær's conception of a more or less common age for the Upper Chasmops, Mjøsa, Sphaeronid and Encrinite Limestones of Norway, and the Kullsberg (Lower Leptaena) Limestone of Sweden. The black Tretaspis (Trinucleus) shales which overlie the Norwegian limestones are regarded as of the zone of *Pleurograptus linearis*, and the limestones are correlated with 4bδ which is regarded by Thorslund (1940) as in the *Dicranograptus clingani* zone. Størmer's correlation table (p. 393) places the Cyclocrinus Beds of the northern region in 4bγ, which Thorslund (p. 183) equates with the zone of *Climacograptus wilsoni* above the zone of *Climacograptus peltifer*.

The contribution of the corals to these correlation problems is a small one, since in the collection studied there is no identity of species from one region to another. This can be seen from the following table (p. 145).

The first point to emerge from this table is that small solitary Rugosa only are represented from the Cyclocrinus Beds and the overlying Sphaeronid Limestone, and that none such occur in either the Mjøsa or the Encrinite Limestone. This may well be a reflection of facies; in the Lower Carboniferous for instance, the fauna of small solitary Rugosa characterises a different sedimentary environment from the large compound corals (Hill, 1948). The individuals are few, and insufficient to show whether the species are common to the two formations, or characteristic of one or other of them. So far, *S. compactum* and ? *Grewingkia* sp. are known only from the Sphaeronid Limestone and *Streptelasma* sp. only from the Cyclocrinus Beds, while *S. curvatum* and *S. holtedahli* may occur in both.

The second point to emerge is that no species is common to the Mjøsa Limestone of Mjøsa and the Encrinite Limestone of the Gjerpen —Langesund district, both of which are characterised by compound corals only, suggesting a reef or near-reef environment. Two genera are common to the limestones, *Eofletcheria* and *Liopora*, but are represented by different species. At first sight this would appear to indicate a difference of horizon; but in each case the Mjøsa species have a greater strength imparted by skeletal thickening, and this may be a reflection of environment rather than difference in age. Nevertheless the difference in the remaining faunas favours a difference of horizon as the cause.

MJØSA	TOTEN	S. HADELAND	GJERPEN — LANGESUND
Mjøsa Limestone	**Sphaeronid Limestone**	**Sphaeronid Limestone**	**Encrinite Limestone**
Eofletcheria subparallela sp.nov.	*Streptelasma compactum* sp.nov.	? *Grewingkia* sp.	*Tryplasma basaltiforme* sp.nov.
E. ? *subparallela* sp.nov.	*S.* ? *curvatum* sp.nov.	*Streptelasma holtedahli* sp.nov. (Chasmops Lst.)	*T. brevikense* sp.nov.
Liopora favosa (McCoy)			*Eofletcheria irregularis* sp.nov.
Nyctopora aff. *parvotubulata* Kiær.			*E.* ? *irregularis* sp.nov.
			Liopora tenius sp.nov.
			Coccoseris tumulosus sp.nov.
		Cyclocrinus Beds	
		Streptelasma curvatum sp.nov.	
		S. ? *curvatum* sp.nov.	
Cyclocrinus Beds			
		S. holtedahli sp.nov.	
Streptelasma ? *holtedahli* sp.nov.			
		Streptelasma sp.	

The evidence offered by the corals on the age of the beds is consistent; the fauna is clearly younger than the Chazy and Black R. (= zone of *Nemagraptus gracilis*) faunas of N. America. The *Streptelasma* of the Cyclocrinus Beds are all more highly developed than those of these American formations, but they show no very close similarities with the Craighead (*C. peltifer* zone) *Streptelasma* of Scotland.

The Mjøsa Limestone contains *L. favosa*, typical of the Craighead fauna, and very similar to *L. americana* from the Trenton of N. America, *Nyctopora* aff. *parvotubulata* which may be conspecific with the type from the Kalstad Limestone whose age however is not yet fixed but in Vogt's opinion (1942, p. 485) is older than the Dicranograptus shale; a correlation with the Craighead Limestone is thus permissable.

The Encrinite Limestone of the Gjerpen—Langesund district contains *Coccoseris tumulosus*; elsewhere no Heliolitidae are known before the Trenton, or before the Craighead Limestone; similar remarks apply to *Liopora*. Cerioid *Tryplasma* like the two Encrinite Limestone species occur in Black R. and Trenton strata in N. America, but are unknown in Great Britain. The corals thus indicate that the Encrinite Limestone is of Trenton age; and the overlying black shales being correlated with the *P. linearis* zone, the limestone must represent part of the graptolite sequence *C. peltifer* — *D. clingani* inclusive. They do not indicate whether it is older or younger than the Mjøsa Limestone, nor do they suggest identity.

Systematic Description.

ZOANTHARIA RUGOSA

Superfamily Streptelasmacea
Family Streptelasmidae
Subfamily Streptelasminae
Genus *Streptelasma* Hall

Streptelasma holtedahli sp. nov.
(Pl. 1 figs. 1, 2).

Holotype: Pal. Mus. Oslo 34228, south of Røykenvik, Hadeland: Cyclocrinus Beds; coll. O. Holtedahl. Another specimen Pal. Mus. Oslo 33878 from Chasmops Limestone, same locality.

Diagnosis: Small slightly curved *Streptelasma*, slightly compressed laterally, with numerous septa and a dense, compressed axial structure.

Description: The corallum is trochoid and but slightly curved, the cardinal fossula being at the outer curve. It is compressed laterally, the diameter just below the calice in the plane of curvature being 15 mm., and at right angles to this being 12 mm. At this diameter there are 39 major and 39 minor septa, dilated and contiguous at the periphery to form a narrow peripheral stereozone about 0.75 mm. wide; between this and the axial structure, which is 5 mm. × 3 mm., the septa are thinner; the interseptal loculus between a minor septum and its neighbouring major septum on the counter side is often narrower than the loculus on the cardinal side, owing to the major septum retaining thickening there, and to the minor septa tending to lean on their neighbouring major septa on the counter side; the minor septa extend about half way to the axial structure. The axial structure is formed by conjunction of the axial edges of the septa and the monacanthine trabeculae projecting from them, and by the deposition of dilating tissue; it is dense, with only occasional irregular loculi. The cardinal fossula is narrow and parallel-sided, and the cardinal septum long.

Remarks: Pal. Mus. Oslo 34544 from the Cyclocrinus Beds of Gjøvikodden, Toten, is placed doubtfully in this species. It is smaller, more erect, does not show lateral compression, and its axial structure is relatively smaller, but its septal characters are similar to those of the holotype.

38174 from the Mastopora Beds of Furuberget, Mjøsa, coll. J. Kiær 1896 is a sectioned fragment which may belong here. It bears the label *Ptychophyllum* sp.

Streptelasma curvatum sp. nov.
(Pl. 1, fig. 3).

Holotype: Pal. Mus. Oslo 34500; Tønnerudodden, Hadeland: Cyclocrinus Beds; coll. J. Kiær.

Diagnosis: Small, regularly curved and regularly conical coralla, with large, parallel-sided cardinal fossula on outer curve; with few and dilated septa.

Description: The corallum is small, regularly curved and rather slenderly conical, attaining a diameter of about 8 mm. at the floor of the calice, which is deep. The external surface shows marked septal furrows and interseptal ridges, the furrows which correspond to minor septa being equally as strong as those corresponding to the major septa. The calice is deep.

The cardinal fossula is at the outer curve of the corallum, and is long, extending to the centre or even beyond. The septa are all dilated, with bluntly rounded axial edges, and the minor septa are very short; some of the major septa show large monacanthine trabeculae near or projecting from their inner edges, in the plane of the septum, so that a primitive streptelasmoid axial structure is present. At a diameter of 5 mm. the long cardinal and counter septa are in contact at the axis, and there are 4 major septa in each counter quadrant, one being the counter-lateral septum; the axial edges of all except the last formed septum are directed towards the inner half of the counter septum; the septa are so dilated as to leave only minute spaces in these quadrants. At this diameter too there are four major septa including an alar septum in each cardinal quadrant; the fossula is wide, long and parallel-sided, being bisected by the long cardinal septum. The septa of the cardinal quadrants are longer than those of the counter quadrants, and although equally dilated are more widely spaced. At a diameter of 6 mm. the interseptal loculi are wider and spaces are developed in the axial structure, but the septal dilatation has not decreased. Though no sections of tabulae are visible in either transverse section, it is assumed that they are present.

Remarks: The large parallel-sided fossula, small size and great septal dilatation of this species distinguishes it from other *Streptelasma*. *S. aequisulcatum* (McCoy) from the Coniston Limestone of Great Britain and *S. kiæri* described below have a similar septal dilatation and axial structure, and it may be that these three are generically distinct from *Streptelasma corniculum*.

Streptelasma ? curvatum.

Three specimens, one (Pal. Mus. Oslo 64503) from the Cyclocrinus Beds of a locality N. of Mjørputten, Hadeland, and two (Pal. Mus. Oslo 34846, 34847) from the Sphaeronid Limestone of a locality N. of Gjøvik, Toten, are similar in external form, size and septal grooving to the holotype of *S. curvatum*. They resemble that specimen also in having the cardinal fossula at the outer curve, and in having elongate cardinal and counter septa. 34847 also resembles the holotype in having a wide, parallel-sided cardinal fossula, but this is not visible in either of the other two. All three have the septa of the cardinal quadrants dilated, but those of the counter quadrants (except the counter septum) are confined in the adult stages either to a narrow peripheral stereozone about 0.5 mm. wide or reduced to thin plates which do not reach the axis, so that matrix fills this part of the corallum. A similar condition in the counter quadrants is found in the specimen described below as *Streptelasma* sp. It is not possibles on the limited material available, to determine whether this weaknes, in the septa of the counter quadrants is a specific character, or some mischance to the three corallites. They are therefore doubtfully included in *S. curvatum.*

Streptelasma compactum sp. nov.
(Pl. 1, figs. 4, 5).

Holotype: Pal. Mus. Oslo 34793—5, Gjøvikodden, Toten: Sphaeronid Limestone; coll. J. Kiær 1925.

Diagnosis: Small trochoid *Streptelasma* with dilated septa and wide dense axial structure of crowded, large monacanthine trabeculae.

Description: The corallum attains a diameter of 12 mm. at the base of the calice, which is 20 mm. wide at its outer edge and 20 mm. deep. The expansion is regular and the corallum curved, the cardinal septum being at the outer curve. Septal furrows are marked, those which correspond to minor septa being developed as strongly as those corresponding to the major septa.

The septa are numerous and dilated so as to be contiguous in a peripheral stereozone about 2 mm. wide at a diameter of 12 mm.; inside this they may thin a little, so as to leave a zone of small, unequal interseptal loculi between the stereozone and the axial structure.

The axial structure which projects into the calice as a tall dome is wide (4—5 mm. in diameter at the base of the calice) and consists of thick monacanthine trabeculae springing from the axial edges of the septa, so closely packed as to show only very small, occasional loculi.

Remarks: The specimen described below as *Streptelasma* sp. from the earlier Cyclocrinus Beds shows a similar wide axial development of large monacanthine trabeculae, but is a smaller corallum with relatively fewer septa, and further shows a weak development of the septa in the counter quadrant, not seen in the holotype of *S. com-*

pactum: it is provisionally regarded as a distinct species, insufficiently known to be given a name. *S. compactum* differs from *S. curvatum* in being larger, without the distinctive parallel-sided fossula of the latter, and in possessing a wide dense axial structure of large monacanthine trabeculae.

Streptelasma sp.

(Pl. 1, fig. 6).

Associated with the holotype of *S. curvatum* there is in the Cyclocrinus Beds of Tønnerudodden, a specimen (Pal. Mus. Oslo 34498) which attains a slightly greater size than the holotype. At a diameter of 6 mm. the septa are continuous plates only in the outer 2 mm. of their course; axially they are represented by separate monacanthine trabeculae forming a loose axial structure; the fossula is not distinct, and the cardinal and counter septa not specially distinguishable in length. The fossula would however appear to be on the outer curve of the corallum as in *S. curvatum*, and at a diameter of 8 mm. an axial region 4 mm. in diameter is occupied by thick monacanthine trabeculae many of which are in contact so that only small spaces are seen. The septa of the counter quadrants are confined to a stereozone 1 mm. wide, but between this stereozone and the axial structure matrix occurs, and one cannot ascertain whether this is due to the deepening of the calice in the counter quadrants or to the weaker development of the septa therein. It seems to me that this specimen represents a species distinct from *S. curvatum*.

Genus *Grewingkia* Dybowski

? *Grewingkia* sp.

(Pl. 1, fig. 7).

Pal. Mus. Oslo 34807; Tønnerudodden, Hadeland: Sphaeronid Limestone; coll. J. Kiær 1925.

This specimen is part of a large solitary corallum with very numerous septa, dilated and contiguous in a peripheral stereozone about 1.5 mm. wide at a diameter of 30 mm., with the major septa extending thence about half way to the axis; the minor septa are less than half as long as the major septa. In the wide axial region inside the septate zone, a few separate denticulate septal lamellae, irregular in course, are based on thin domed tabulae. The number of lamellae is small, but the axial zone is wide; it is therefore doubtful whether the specimen is better placed in *Grewingkia* or *Brachyelasma*, but in the absence of young stages, *Grewingkia* seems the more likely.

Superfamily Cystiphyllacea

Family Tryplasmidae

Genus *Tryplasma* Lonsdale, 1845.

Genotype: — *T. aequabile* Lonsdale, 1845, pp. 613, 633, pl. A, figs. 7, 7a; R. Kavka, east side of northern Ural Mts., Russia: Silurian. See Lang, Smith and Thomas, 1940, p. 135.

Massive, fasciculate or solitary coralla; corallites with numerous septa each consisting of a single vertical series of inclined trabeculae, free at their inner ends but united by their bases; tabulae are horizontal or gently sagging, sometimes with a median notch; no dissepiments. Ord.-Dev.

Two cerioid species from the Encrinite Limestone of Norway are here included in this genus, together with *Columnaria halli* Nicholson of Lambe (1901, pl. vi, figs. 2, 2a) from the Black R. Limestone [Zone of *Nemagraptus gracilis*] at Stewart's Qy., near Sand Point, on the Ottawa R., a few miles west of Arnprior. They share with the fasciculate *T. rugosum* (Ed. and H.) the possession of one order only of septa, which are however unequal in length. Their general appearance is favositoid, and one might easily place them in this family were it not for the complete absence of mural pores. It is possible that they belong to *Foerstephyllum* Bassler, 1941 p. 1961, 1950, p. 269; but *Columnaria*? *halli* Nicholson, 1879, the designated type species, seems to me, as to Nicholson, to be Nyctoporid when interpreted on the specimen figured by Nicholson, whilst Bassler's interpretation of *C. halli*, which is clearly also Lambe's (1901, pl. vi, figs. 2, 2a) is tryplasmid. There is here a taxonomic problem which can only be properly solved by reference to Nicholson's syntypes. It may be that among these there is a specimen with the morphology figured by Lambe and by Bassler, and if so it could become the lectotype; this would then safely attach the name to the morphology Bassler intended it for. As such the genus *Foerstephyllum* is closely related to *Tryplasma*, which is based on a fasciculate type species, *T. aequabile*, and may even be a subgenus of *Tryplasma*, its distinguishing character being its cerioid form. Should *Foerstephyllum* be standardised as suggested, the two cerioid species described below may be referred to *Tryplasma* (*Foerstephyllum*).

Silurian *Tryplasma* at least have rhabdacanthine trabeculae which may on recrystallisation appear holacanthine; in the much recrystallized Ordovician cerioid forms also the trabeculae appear holacanthine.

Tryplasma basaltiforme sp. nov.
(Pl. 1, fig. 8).

Holotype: Pal. Mus. Oslo 8585; Ås, Frierfjorden, Gjerpen—Langesund; Encrinite Limestone.

Diagnosis: Cerioid *Tryplasma* with corallites 2.5—3 mm. in diameter, and with one order only of unequal septa.

Description: The corallum is probably hemispherical, but is known from two fragments only (Pal. Mus. Oslo 8585 and 8588), the larger being 65 mm. in diameter and 40 mm. tall, the corallites radiating from a point. The corallites are straightsided, polygonal, 2,5 to 3 mm. in maximum diameter. There are 18 to 20 septa, apparently of one order only, unequal, but all wedge shaped in transverse section, thickening towards the periphery, where by contact laterally they form a stereozone 0.6 mm. wide. Each septum is seen in vertical sections to consist of a single vertical series of trabeculae which are free at their inner ends, but in contact at their bases. The coral tissue has been recrystallised into a calcite mosaic in which there is no trace of the lamellar arrangement around the holacanths seen in Silurian fasciculate *Tryplasma*, nor any trace of the rhabdacanthine nature of the trabeculae, which is presumably the unaltered condition (Hill, 1936). The tabulae are gently sagging, horizontal or occasionally with a median notch, and are unequally spaced. There are no dissepiments. Mural pores do not occur.

Remarks: Kiær's name (1879) for this coral was *Columnaria* cf. *halli* Nich., and I agree that the form is close to the species figured under that name by Lambe (1901, pl. vi, figs. 2, 2a) from the Black R. limestone of Stewart's Qy., near Sand Pt., lot 18, concession 11, township of McNab, a few miles west of Arnprior on the Ottawa R., Ontario, Canada; but I think it not closely related to *Columnaria halli* Nicholson (1879, pl. x, fig. 3), from an unstated locality in the Black R. or Trenton of the U.S.A. or Canada, which seems to me to be a nyctoporid. It differs from Lambe's figured specimen in the angle of inclination of its trabeculae; they are directed inwards and a little upwards in the Norwegian species, but are horizontal in the Canadian form.

This species is distinguishable from *T. brevikense* sp. nov. by the greater diameter of its corallites, *T. brevikense* having corallites of only half the diameter of those of *T. basaltiforme*. It is known so far only from the Encrinite Limestone of Norway.

Tryplasma brevikense sp. nov.
(Pl. 2, figs. 9—11).

Holotype: Pal. Mus. Oslo 8528; Quarry at Skjellbukta north of Brevik, Frierfjorden: Gjerpen—Langesund district; Encrinite Limestone.

Diagnosis: Cerioid *Tryplasma* with very slender corallites (1 to 1.5 mm. in maximum diameter), each with one order only of unequal septa.

Description: The corallum forms large masses, tall, or spreading; one fragment 9 × 12 × 3 cm. tall probably represents only one third of a corallum; another is 7 cm. tall, and 8 mm. wide; its general habit resembles that of massive *Favosites*. The corallites are very slender and unequal, 1 to 2 mm. in maximum diameter, with straight or curved, unequal sides, and 4- to 6-sided. On the upper surface of the holotype, portions of the corallum grew upwards in knobs in which the corallites were all about 2 mm. diameter, whereas in the other parts of the corallum the average was 1 mm. or a little over. The corallites show wavy walls in parts of the vertical section indicating expansions and contractions of diameter. The septa are short, apparently all of one order, but unequal in size, thickening wedgwise towards the periphery, and expanding more rapidly at the periphery to form a very slender peripheral stereozone. There are from 16 to 20 septa in each corallite, and those of neighbours may alternate or be placed back to back. In vertical sections each septum is seen to consist of a single vertical series of equal thornlike trabeculae, directed inwards with little upwards inclination, free over most of their length, but forming a continuous vertical base. The tabulae are complete, horizontal, slightly domed or gently sagging, occasionally with a median notch, and not very regularly spaced. There are no dissepiments and no mural pores. Alteration during recrystallisation has obscured the original structure, and one cannot distinguish any rhabdacanthine condition in the trabeculae, nor any lamellation such as occurs in many recrystallised Silurian *Tryplasma*.

Remarks: Pal. Mus. Oslo 8532—34 from the type locality belong to this species. The growth form, the slender corallites and the spinose unequal septa all suggest that this species is a *Favosites*, but close microscopic study convinces me that mural pores are not present; and the similarity of the form to *T. basaltiforme* in all but size of corallite leads me to place it with that species in *Tryplasma*.

ZOANTHARIA TABULATA

Family Syringoporidae de Fromentel 1864.

Genus *Eofletcheria* Bassler 1950

Genotype (by original designation): *Columnaria incerta* Billings, 1859, p. 428, Mingan I., Gulf of St. Lawrence: Chazyan, M. Ord.

Bushy colonies of slender cylindrical corallites; increase lateral and frequent, offsets diverging immediately or at first parallel to and in contact with parents, so that small sections of the corallum may be cerioid with two or three rows of two or three corallites in contact for some short distance, or so that a halysitoid chain may form temporarily; corallites with a moderately wide peripheral stereozone, consisting of crowded, short, thick, monacanthine trabeculae in vertical series in contact laterally; the inner thin ends of the trabeculae sometimes project free from the stereozone; tabulae typically rare, horizontal, sagging or with a median notch, sometimes incomplete. No perforations through the walls in cerioid portions. Middle and Upper Ordovician, N. America and Scandinavia.

The fibres of $CaCO_3$ forming the stereozone which lines the epitheca appear in the less recrystallised material to be grouped in numerous thick monacanthine trabeculae laterally in contact; in some forms the thin inner ends of trabeculae project freely from the wall, and appear in tangential sections of the corallites as separate dots. The lining is much thicker in some colonies than in others, and in some parts of a corallum than in others. There is considerable variation in diameter of corallites within the one corallum, and in the rapidity or slowness of divergence of offset from parent.

The genus might well have been the ancestor for the Auloporidae, Syringoporidae, Halysitidae and Calapoeciinae, the first by the assumption of a reptant habit for the early parts at least of the corallites; the second by the development of connecting tubules and infundibuliform tabulae; the third by fixation of the chain-like habit of increase and the con-divergence of the offsets and the last by the corallites crowding together and having their walls pierced between the trabeculae first by horizontal rows of perforations and later by horizontal tubular canals.

Eofletcheria irregularis sp. nov.
(Pl. 2, fig. 12, pl. 3, fig. 14).

Holotype: Pal. Mus. Oslo 66261; North side of Skjellbukta, Frierfjorden, Gjerpen—Langesund district: Ordovician, Encrinite limestone.

Diagnosis: *Eofletcheria* with corallites of average diameter 1.5 mm., with offsets usually diverging more or less widely, but sometimes with parallel growth.

Description: The corallum is bushy, the cylindrical corallites having no particular regularity of growth; in oblique sections the corallites are seen to be more often united in groups of two, three or four than alone; increase is lateral and frequent, and the offset may run horizontally for 1 mm. or so before growing upward; or an offset may grow upward immediately, and remain in contact with the parent on one side; such parallel growth may result in one or two rows of two or three corallites forming a halysitoid or cerioid portion of the corallum temporarily. The corallites vary in diameter from about 1 mm. to about 1.8 mm., but the average diameter seems to be about 1.5 mm. The stereozone is rather thick, up to one third of the diameter of the corallite, though more frequently one quarter of the diameter of the corallite. Recrystallisation has replaced the originally fibrous lining by a calcite mosaic, so that trabeculae are no longer distinguishable. Tabulae are seen here and there, thin plates stretching horizontally or sagging gently from lining to lining. No trace of perforations in the common walls is noted when the corallites are joined together.

Remarks: Two other specimens, Pal. Mus. Oslo 66264 and 66263 from the same locality as the holotype, show similar characters to the holotype. One other specimen, Pal. Mus. Oslo 8536 from the same locality is referred to this species, though the average diameter of its corallites is smaller.

One fragmentary specimen, Pal. Mus. Oslo 8534, also from the same locality is characterised by a bushy growth, in which each branch of the bush is a cerioid portion of the colony in which two or three rows of two or three corallites are in contact one with another; the average diameter of the corallites is the same as in the holotype of *E. irregularis*, but the lining is a little less thick. Since only one fragment is available I am in doubt whether this represents a separate species, and so I include it doubtfully in *E. irregularis*. Specimen 8563 is very like 8534 described immediately above, and with it is doubtfully included in *E. irregularis*.

Eofletcheria subparallela sp. nov.
Pl. (3, figs. 15—17).

Lyopora incerta Billings, Kiær, 1930 p. 62, non *Columnaria incerta* Billings, 1859 p. 428, non *Fletcheria incerta* Bill., Lambe, 1899, p. 48.

Holotype: Pal. Mus. Oslo 66294; Loddvik, Helgøya, Mjøsa: Mjøsa Limestone. Fragments Pal. Mus. Oslo 66290—93, and 66295 I take to be fragments cut or broken from the holotype by Kiær, when preparing thin sections. Collected by J. Kiær, 1896.

Diagnosis: Eofletcheria with corallites of average diameter 2 mm or more; the corallites are sub-parallel and rather close in growth.

Description: In the holotype the corallites vary considerably in diameter, from 1 mm. to 3 mm.; and the average seems to be about 2 mm. or a little more; they are sub-parallel, and rather crowded, though the corallites themselves would occupy less space in a corallum than the interstitial mud. Corallites may grow to a considerable length — 15 mm. or more, without giving rise to an offset; offsets are of small diameter (1 mm.) at their origin, but gradually attain a diameter of between 2 and 3 mm. Offsets diverge but slightly from the parents, so that growth is subparallel, and in many parts of the corallum neighbouring corallites are in contact or almost so. Where corallites nearly touch, transverse wrinkles may extend and actually make contact. Vertical sections show that in these corrugations the entire stereozone is involved, and sometimes the lumen itself widens into the wrinkle. A similar but tighter wrinkling in the wall is seen in *Reuschia* Kiær and in some cerioid forms such as *Liopora* and in the syringoporid *Roemeria.* No perforations are seen through the common walls when neighbouring corallites are in contact; the walls usually do not entirely lose their curvature at the contact, the smaller corallite accommodating itself to the other. The fibrous lining to the epitheca is of only moderate thickness, and only occasionally may free ends of trabeculae be noted projecting inwards from it. Tabulae are frequent and thin, usually horizontal or sagging, sometimes with an axial notch; sometimes a plate does not stretch completely across the corallite, and its inner edge rests on the lower tabula; they may be 0.5 to 2 mm. apart.

Remarks: Specimens from the Mjøsa Limestone of the quarry south of Bergvik, Helgøya, Mjøsa District, differ from the holotype and the other specimens from Loddvik in that the corallites attain a slightly greater diameter, varying from 1.5 to 3.5 mm., with an average of nearly 3 mm.; the lining to the wall is relatively thicker also, and some of the tabulae may be thickened. These specimens are included under *E. subparallela* for the time being.

Specimens from the Mjøsa limestone of the railroad cut north of Eina Station, Toten District, Norway, differ from the holotype in having corallites much smaller in average diameter, with less variation, nearly all being between 1.1 mm. to about 1.5 mm.; the stereozones are relatively thicker, and the spine-like inward projections of the trabeculae are more numerous and clearly seen; recrystallisation seems to have affected the corals from this locality less than those from Loddvik and the quarry S. of Bergvik. Corallites are more frequently in contact here also, and the walls usually lose their curvature to become linear along the contacts. I include these specimens doubtfully in *E. subparallela.*

Kiær (1930, p. 56) identified this species with *Fletcheria incerta* (Billings), and transferred the latter to *Liopora* Nicholson and Etheridge. It seems to me that Bassler's new genus *Eofletcheria,* based on Billing's species is generically distinct from the cerioid *L. favosa* (McCoy), the genotype of *Liopora,* which has perforate walls. But I agree with Kiær in noting that *Liopora* sp. could have arisen from it.

The Norwegian species differs from the N. American *Eofletcheria incerta* (Billings) as figured by Okulitch (1937, pl. xviii, figs. 2—4) from the Chazy of the Mingan Is., in the average diameter of the corallite; in *E. incerta* this is 1.2 mm., which is much smaller than that in the Norwegian forms. The corallites in the N. American species also seem much closer packed in the corallum, but *E. subparallela* and *E. incerta* are similar in septal and tabular characters, and in transverse wrinkling. *E. subparallela* differs from *E. aperta* in growth form and in the greater development of tabulae, and from *E. irregularis* in growth form and calical diameter.

Genus *Reuschia* Kiær 1930.

Genotype (by monotypy): *R. aperta* Kiær, 1930, pp. 54, 63, pl. iv, figs. 1—3, and text-figs. 5 on p. 27 and 9a, b on p. 55; Stord, Ostralsten, Bergen Region, Norway: Upper Ordovician. (Plate 5, figs. 26a—c).

Bushy corallum with lateral increase and diverging cylindrical corallites; corallites with a septal stereozone so thick that the lumen may be almost or completely filled. The septa do not show free spines along their axial edges, and there are no tabulae. The walls of neighbouring corallites are transversely wrinkled at regions of juxtaposition.

The lectotype of *R. aperta* has been sectioned, by kind permission of G. Henningsmoen, and found to differ from the Middle Ordovician species herein referred to *Eofletcheria* Bassler, in having its septa so long and dilated as completely or almost completely to close the lumen, which is not crossed by tabulae, and in not having free spines projecting axially from its septa. The genus may well have developed from *Eofletcheria* by an increase in the length and dilatation of the septa, in which it resembles the Upper Palaeozoic genus *Cladochonus* McCoy. In the transverse wrinklings of the corallite walls where corallites are contiguous, this species resembles *E. subparallela* Hill and some cerioid forms such as *Liopora* and *Roemeria*.

Family Calapoeciidae

Subfamily Calapoeciinae

Genus *Liopora* Nicholson and Etheridge 1878.

Genotype (by monotypy, see Lang, Smith and Thomas, 1940, p. 78): — *Palaeopora ? favosa* McCoy, 1850; limestone and shale, Craighead, near Girvan, Ayrshire, Scotland: Ordovician [? *Climacograptus peltifer* zone].

Massive coralla with polygonal corallites in which each corallite has a single peripheral ring of ? 20 vertical series of slightly inclined thick trabeculae those of neighbouring corallites alternating or opposed; the thick double walls so formed may be pierced in horizontal zones by a row of irregular rounded pores each caused by a local thinning of the trabeculae; the tabulae are distant and sagging slightly.

The genus is known from the *C. peltifer* zone (Craighead Limestone) in Scotland; the Kalstad Limestone, Mjøsa Limestone, and Encrinite Limestone in Norway; and the Trenton (Jacksonburg Limestone) of New York, U.S.A. (somewhere between *C. peltifer* and *D. clingani* zones inclusive).

It seems simpler in structure than the closely related *Calapoecia*; in both *Calapoecia* and *Syringophyllum* the short vacuites noted between the trabeculae in *Liopora* develop into quite long horizontal canals, floored and roofed with extensions of the tabulae and bounded laterally by peripheral prolongations from the trabeculae.

Liopora favosa (McCoy)
(Pl. 4).

Palaeopora ? favosa McCoy, 1850, p. 285, described and figured as *Palaeopora favosa* McCoy, 1851, p. 15, pl. 1c, figs. 3, 3a—d; limestone and shale Craighead, Girvan, Scotland: Ordovician, [? *Climacograptus peltifer* zone].

Lyopora favosa; Nicholson and Etheridge, 1878, p. 26, pl. ii- figs. 1—1e.

Lyopora favosa; Kiær, 1930; *Lyopora favosa*; Cox, 1936, p. 27. pl. ii, figs. 3, 4. *Liopora favosa:* Lang, Smith and Thomas, 1940, p. 77.

Type material: In the Sedgwick Museum, Cambridge.

Diagnosis: Liopora with moderately thick walls.

Description: Thickwalled *Liopora* occurs in several localities within the Mjøsa Limestone of Helgøya in L. Mjøsa, Norway. Pal. Mus. Oslo 66273, 66274 are from the *Stromatopora* limestone of Nordre odde, Bergvik; Pal. Mus. Oslo 66270 from the quarry south of Bergvik; Pal. Mus. Oslo 66266 from Bergvik; 66267 Pal. Mus. Oslo from Lervik ?, and 66276 from Loddvik.

There is considerable variation amongst these specimens; in the one corallum the thickness of trabecular tissue between two tabularia may vary from 0.5 mm. to more than 1 mm. though the mode is near to 1 mm.; in 66267 the corallites are nearly filled by the great development of this tissue. The average diameter of corallite left free from this trabecular tissue is 1.3 mm. in 66273, 2 mm. in 66274 (these two coralla being from the same locality), 1.5 mm. in 66276 and 66266, and 2 mm. in 66270; in 66267 there is only a narrow central space about 0.5 mm. left in many corallites, and the smaller corallites are closed altogether. The measurements given by Nicholson and Etheridge are, for average thickness of trabecular tissue, 1.8 to 2 mm. and for average diameter of corallite left free from this tissue, 2 to 3 mm. On these measurements the Norwegian specimens seem to have smaller corallites with thinner trabecular tissue than the Scottish ones, but the thin sections from the type material figured by Cox (1936, pl. ii, figs. 3 and 4) show that actually the dimensions in the two countries are similar.

A study of the trabecular tissue brings out several points of interest. In many corallites or parts of corallites it can be resolved into vertical series of trabeculae which incline upwards and inwards and are in contact with one another; each vertical series is in contact with its neighbouring series, with notable exceptions. Frequently, just above a tabula, the trabeculae may thin, leaving a not very regular space between neighbouring vertical series, each space about the height of one trabecula; where the trabecular series of neighbouring corallites are simultaneously affected, a communication canal is formed between their tabularia. Another type of channel is seen due to transverse wrinklings on the walls of two neighbouring corallites; the space between the outwardly projecting wrinkles is often filled with mud, and this gives a banded appearance to the vertical section.

Tabulae are usually slightly thickened and gently sagging, though a deep, narrow, median notch may occur; in some coralla and in some parts of coralla they are more distant than in others.

Remarks: A comparison of the Norwegian material from the Mjøsa Limestone with Cox's (1936) figures of the genotype convinces me of their equivalence. By a development from the horizontal series of openings, *Calapoecia* may evolve.

Specimen 66267 from Loddvika, Helgøya, collected by W. C. Brögger has its corallites almost completely filled by the inward growth of the tightly packed trabeculae, but since only this specimen is known with this character, it is placed for the present under *L. favosa* (McCoy).

In Scotland *L. favosa* is known only from Craighead, Girvan, in shales believed equivalent to the *Climacograptus peltifer* zone.

Liopora tenuis sp. nov.
(Pl. 5, fig. 23).

Holotype: Pal. Mus. Oslo 8529, from the Encrinite Limestone of the quarry at Skjellbukta, Frierfjorden, Gjerpen—Langesund district, Norway.

Diagnosis: Liopora with thin walls.

Description: The corallum is massive and tall, the holotype being a fragment 75 mm. wide and over 100 mm. tall. The corallites are polygonal, and the dividing walls between the corallites are 0.25 to 0.5 mm. thick, leaving tabularia from 1.5 to 2 mm. in diameter; the walls tend to round out the tabularia at the angles of the polygons. Over most of the corallum the walls are completely replaced by a recrystallisation mosaic of $CaCO_3$; in the calices they are seen to consist of extremely short, thick trabeculae separated just above the tabulae by irregular open spaces in a horizontal row. Tangential sections of corallites taken through walls show this relation between tabulae and the development of spaces between the trabeculae very well; the spaces seem to be due to a thinning of the septa there. The tabulae are sagging gently, complete, and spaced unequally, 0.5 to 2 mm. apart.

Specimens Pal. Mus. Oslo 8580 and 8581 from the same locality are placed in this species; recrystallisation has affected them much more than the holotype.

Remarks. The thin walls of this species are characteristic.

Subfamily Nyctoporinae.

Small coralla; corallites with 16 short septa alternating in size. M.-U. Ord.

Two genera only are at present assigned to this subfamily, *Nyctopora* Nicholson and *Billingsaria* Okulitch; the latter is the older occurring in the Chazy of N. America, and has thick walls and septa, while some of the corallites have a columella; the former may have thin walls. Communication between adjoining tabularia is attained by vacuities between neighbouring septa; these vacuities may be arranged in horizontal rows as in *Liopora*, suggesting a relation to the Calapoeciinae.

Genus *Nyctopora* Nicholson 1879.

Genotype (by monotypy): *N. billingsi* Nicholson 1879, p. 184. pl. ix, figs. 3, 3a—c = *Columnaria goldfussi* Nicholson 1875, p. 9, Ordovician, Trenton limestone, Peterborough, Ontario, Canada. (non *C. goldfussi* Billings, 1858, p. 166 which is a heliolitid).

Small spherical or pyriform coralla with slender corallites; the short septa are not regularly radial, and frequently alternate in length, and are up to 16 in number, 8 usually being outstanding; tabulae are horizontal and frequent; spaces may occur between the trabeculae of neighbouring septa so that the tabularia of adjoining corallites communicate. No columella. Trenton of N. America, Mjøsa Limestone, and 5a of Stord, Norway.

If a specimen in the British Museum from the Trenton of Nepean Pt., Ottawa, Ontario is correctly assigned to *N. billingsi*, the species may develop horizontal rows of vacuities between trabeculae, just as in some *Liopora*.

Nyctopora aff. *parvotubulata* Kiær
(Pl. 5, fig. 24).

Holotype: Nyctopora (?) *parvotubulata* Kiær, 1932, p. 106, pl. 13, figs. 1—4, Kalstad Limestone, Meldalen, Trondheim Region, Norway. (? Zone of *C. peltifer* or *D. clingani*).

Diagnosis: Nyctopora with corallites 0.7—0.9 mm. in average adult diameter.

Description of thin sections of specimens from the Mjøsa Limestone. Two thin sections labelled Mjøsa Limestone, one marked g, have probably been prepared from a small fragment Pal. Mus. Oslo 66265, from the Mjøsa Limestone of Loddvik, Helgøya, Mjøsa, which has with it a label "cf. *Stylaraea* (?) *occidentalis* Nich. and Eth.", probably from an identification by Kiær.

The corallites are approximately 1 mm. in average diameter and are 4 to 6 sided. The tissue between the tabularia is of trabeculae, the lines of contact between neighbouring trabeculae being clear in the sections; there is no epithecal line of division between neighbouring corallites; this tissue may be as little as 0.2 mm. thick but the trabeculae forming the septa of neighbouring corallites are sometimes separated by one or two additional trabeculae and the tissue between two tabularia may then be as much as 0.5 mm. thick; often the trabeculae of eight septa extend further into the tabularia than those of the remaining septa, which are extremely short and alternate with the longer ones; the septa are not regularly radial; neighbouring septa may not be contiguous throughout their height, pores thus occurring in the wall, permitting communication between the tabularia of neighbouring corallites; but these pores are not regular round holes as in *Favosites*; they are like the less regular spaces found in *Liopora.* No columella is visible in the tabularia. Tabulae are complete, very slightly arched or saucered, two to 1 mm. on the average.

Remarks: This specimen resembles the specimen figured by Kiær loc. cit. figs. 3, 4 fairly closely; but in the Mjøsa form spaces are visible between neighbouring trabeculae, allowing communication between tabularia, and the tabulae are only half as widely spaced. In view of our ignorance of the limits of variation in Kiær's species, the present specimen is described as *N. aff. parvotubulata* Kiær. It resembles the Canadian Trenton *N. billingsi* Nich., the genotype, fairly closely, but the figures given by Nicholson do not show whether addition trabeculae may appear between the septal trabeculae of adjoining corallites, nor whether an epitheca is present or not between corallites; the vacuities between trabeculae in *N.* aff. *parvotubulata* are less regularly round than suggested by Nicholson's figures.

In its interstitial trabeculae this Norwegian specimen recalls early *Propora,* particularly *P. goldfussi* (Bill.) but it has not the fixed number 12 of septa, characteristic of the Heliolitidae.

Family Heliolitidae Lindström 1876
Subfamily Coccoserinae Lindström 1899
Genus *Coccoseris* Eichwald 1855.

Genolectotype (chosen Lang, Smith and Thomas, 1940, p. 39): *Coccoseris ungerni* Eichwald, 1855[2], p. 2, explanation of pl. xxv, figs. 4a—c, and 1860, p. 442 = *Lophoseris ungerni* Eichwald, 1855[1], p. 466 [Ordovician], Orthoceras Limestone: Lyckholm, near Hapsal; and Dolomitic Limestone with *Platystrophia lynx:* Kirna and Borkholm, Estonia.

Corallum discoid, or in tumular expansions. Each calice with 12 triangular septa, surrounding numerous papillae in the central area; no tabulae; coenenchyme with narrow, shallow funnel-shaped tubes, enclosed by thick compact walls, often papillose or scrobiculate on the edges, the walls being entirely composed of large monacanthine trabeculae. M. and U. Ord.

Lindström (1899) described four species under this genus, *C. ungerni* Eichwald with calices 1.5 to nearly 2 mm. in diameter, *C. microporus* (Eichwald), with calices nearly 1 mm. in diameter, *C. megastoma* (McCoy) with calices 1.5 mm. diameter, and *C. micraster* Lindström with very small calices, 0.3 mm. in diameter. Lindström stressed the growth habit of the genus as thin lamelliform; in *C. ungerni* in some coralla successive lamellae grew one above the other to give a moderately thick corallum, but in the only specimen he had of *C. micraster* the corallum was a sphaeroid 13 mm. in diameter. He regarded the genus as distinct from *Protaraea* Edwards and Haime 1851 in that *Protaraea's* coenenchyme was comparatively very narrow or absent. This distinction seems to me valid, though Kiær (1904) preferred to unite *Coccoseris* with *Protaraea*.

Kiær (1904) considered that certain forms which he had previously (1899) assimilated to *Palaeopora inordinata* Lonsdale were conspecific with Lindström's *C. micraster*, and he made this species the type of his new genus *Trochiscolithus* Kiær 1904 by monotypy. The forms involved were (a) thin encrusting to strongly branched coralla, with transitional cake-like forms, from 5a of Ringerike, Tyrifjord; the calicles were 0.8 mm. wide in this group, distant in wide coralla, but close in branches; (b) cake-like or knobby coralla from 5b, Ringerike, up to 100 mm. in diameter and 40 mm. thick; (c) flat, wide coralla up to 150 mm. diameter and 15 mm. thick, from F_1, Piersal, Estland. The coenenchyme is poorly developed in all save the broad forms from 5a Ringerike. The branching coralla from 5a Ringerike differ from the others in having an unthickened axial region. It seems to me that the specific identity of this branching form with lamellar or cake-like forms requires proof, and that it is wise in the meantime to use the generic name *Trochiscolithus* only for those branching forms with unthickened axial regions, leaving the cake-like and lamellar forms with thickened tissue in *Coccoseris*.

Kiær (1904) remarked that two specimens in Lindström's collection from F of Estland were identical with the compact community (c) from F_1 Piersal, Estland described by Kiær (1899) as *P. inordinata* Lonsdale; and on the museum label for these specimens Lindström had written, after his "Remarks on the Heliolitidae" had been published, *Trochiscolithus stellifer* gen. et sp. nov. Since *P. inordinata*

Lonsdale was still a puzzling species, Kiær proposed (p. 4) to regard his Baltic specimens as *Trochiscolithus* but recognised only one species with two growth forms; one, the branched lamellar form of 5a of Ringerike, and the other the compact, thick spherical form called *T. stellifer* Lindström MS. Both of these he identified with *Coccoseris micraster* Lindström which he transfered to *Trochiscolithus*.

As museum labels have no validity in taxonomy, it seems that *Trochiscolithus* must be ascribed to Kiær 1904, with its species by monotypy, *T. micraster* (Lindström) as understood by Kiær, 1904.

It seems to me very likely that Lindström's specimen of *C. micraster* may not be conspecific with the 5a forms described by Kiær, for the calical diameter given by Lindström is 0.3 mm, this being the smallest amongst the heliolitids he examined, and its tissue is thickened throughout, while the 5a form has an average calical diameter of 0.8 mm., and in the branched forms the tissue in the axial regions of the branch is unthickened. Probably the specific name *micraster* should be confined to those spherical coralla with very small calicles (0.3 mm. diameter) and tissue thickened throughout so that the coenenchyme below the surface is quite dense, and a new name should be found for that part of *micraster* Lindström of Kiær from the 5a beds of Ringerike.

Kiær described the walls and septa of *Trochiscolithus* as porous; the pores in the wall are quite other than those of the Favositidae; they are irregular spaces left by the impersistence vertically of one or more of the monacanthine trabeculae (baculi of Lindström).

Coccoseris tumulosus sp. nov.
(Pl. 5, fig. 25).

Holotype: Oslo 66260; north side of Skjellbukta, Frierfjorden, Gjerpen—Langesund district; Encrinite Limestone.

Description: The corallum is cake-like, with an irregular, tumular upper surface and thin at the margins. Its diameter is more than 60 mm and one specimen (Pal. Mus. Oslo 66259) was 40 mm. thick at least in the middle parts. Some of the growth lamellae have had their upper surface stained with a dark stain along the median lines of the septa and baculi; and there may be two or three of these lamellae in one mm.

The calical depressions on the upper surface of the colony appear to have a diameter of 0.75 mm. approx.; but this is less than the actual diameter of the septate tubes, which is 1 mm. when measured in thin transverse section; the centre of one depression may be about 1.5 mm. from the centre of its neighbours, so that the width of coenenchyme as seen on the surface between the depressions seems about equal to the diameter of the depression; but in thin transverse section the width is seen to be less — up to about 0.5 mm. Each depression has a raised central part, a little over one third its diameter The coenenchyme between depressions is ridged on the weathered surface, the ridges forming an irregular network, but papillate on unworn surfaces.

In thin transverse section each calice is star-shaped, its diameter from the outer edges of the star being 1 mm. approximately; the twelve septa are triangular, each may have a thin median zone stained black or dark brown; in those parts of the corallum unaffected by recrystallisation, the tissue of the septa almost completely fills the outer parts of the star, but near cracks and where solutions have filtered into the corallum, all the coral tissue except that in the position of the median dark line may be clarified by recrystallisation so that a false appearance simulating the thin-tissued axial region of *Trochiscolithus* is seen. The wide axial region of each star is filled by up to 6 thick vertical trabeculae separate from the septa, so that it is very distinct from the septate outer portion. The coenenchyme is about 0.5 mm. wide between the stars. It consists of monacanthine trabeculae so arranged that the lines joining their mid-points form a network; each trabecula (baculus) is so thick however that the spaces (tubules) of the network are infilled immediately below the calicular surface. There may be two to four rows of these tubuli between stars. Sometimes a trabecula fails to develop to complete a network, and this failure causes an irregular space to arise. In vertical section the tissue is seen to be of thick trabeculae packed together, and no tabulae are seen.

Remarks: In the size of its corallites and the width of the coenenchyme between them, this form resembles *Coccoseris microporus* (Eichwald) as described by Lindström (1899, p. 107) from Borkholm and Hurküll in Estonia, but the axial region of discrete trabeculae is relatively wider in these higher forms, which are also very thinly laminar in growth, not thick and cake-like as in our Encrinite Limestone species. It also recalls Kiær's description of the cake-like forms from F_1 of Piersal, Estonia, which he referred first to *Palaeopora inordinata* Lonsdale and later to *Trochiscolithus micraster* Lindström. It differs from *C. micraster* Lindström in the greater size of its calicles (0.75— 1 mm. as against 0.3 mm.).

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PLATES 1–5

EXPLANATION OF PLATES

All specimens are in the Palaeontological Museum, Oslo.

Plate 1.

Fig. 1. *Streptelasma holtedahli* sp. nov. Holotype, Pal. Mus. Oslo 34228; Cyclocrinus Beds, south of Røykenvik, Hadeland, Coll. O. Holtedahl, trans. section × 2.

Fig. 2. *Streptelasma holtedahli* sp. nov. Pal. Mus. Oslo 33878, Chasmops Limestone, south of Røykenvik, Hadeland; trans. section × 2.

Fig. 3. *Streptelasma curvatum* sp. nov. Holotype, Pal. Mus. Oslo 34500, Cyclocrinus Beds. Tønnerudodden, Hadeland, coll. J. Kiær; 3a, 3b Pal. Mus. Oslo trans. sections × 4.

Fig. 4. *Streptelasma compactum* sp.nov. Holotype, Pal. Mus. Oslo 34793—5, Sphaeronid Limestone, Gjøvikodden, Toten, coll. J. Kiær 1925; trans. section, 4a × 2, 4b × 4.

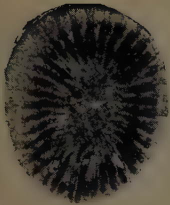
Fig. 5. *Streptelasma compactum* sp. nov. Pal. Mus. Oslo 34796, same locality and horizon as fig. 4; vert. section × 2.

Fig. 6. *Streptelasma* sp. Pal. Mus. Oslo 34498, Cyclocrinus beds, Tønnerudodden, Hadeland, coll. J. Kiær; 6a, 6b trans. sections × 4.

Fig. 7. ? *Grewingkia* sp. Pal. Mus. Oslo 34807, Sphaeronid Limestone, Tønnerudodden, Hadeland, coll. J. Kiær; trans. section × 2.

Fig. 8. *Tryplasma basaltiforme* sp. nov. Holotype, Pal. Mus. Oslo 8585, Encrinite Limestone, Ås, Frierfjorden, Skien; 8a × 2, 8b × 4.

PLATE 1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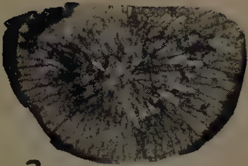
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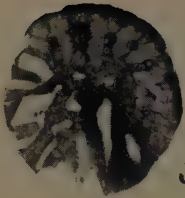
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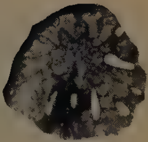
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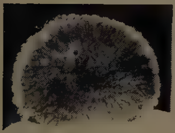
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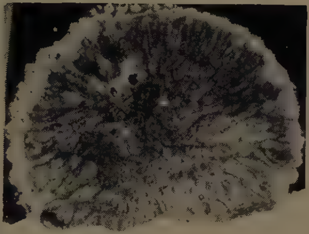
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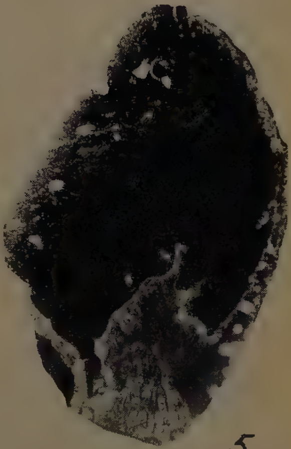
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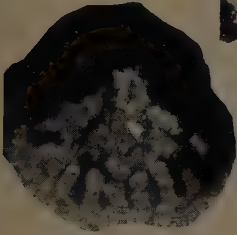
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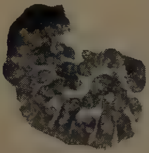
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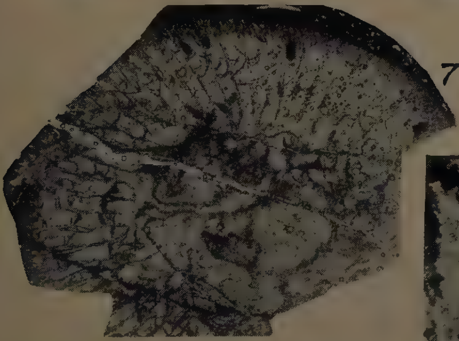
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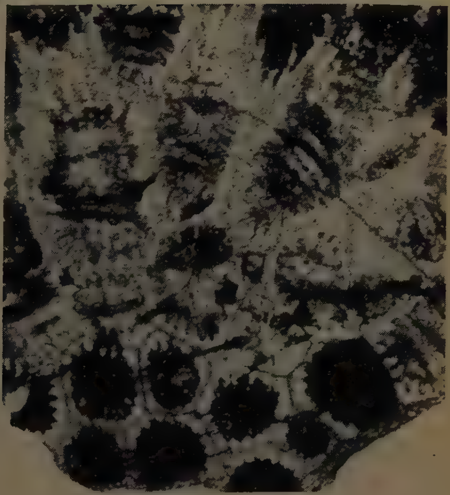
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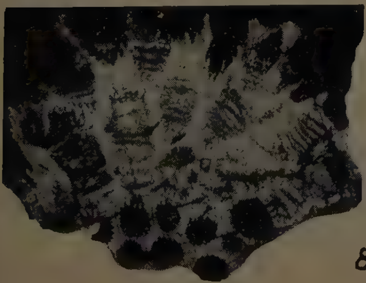

8a

Plate 2.

Fig. 9. *Tryplasma brevikense* sp. nov. Holotype, Pal. Mus. Oslo 5828, Encrinite Limestone, Quarry at Skjellbukta, Frierfjorden, 9a trans. section × 2, 9b vert. section × 2.

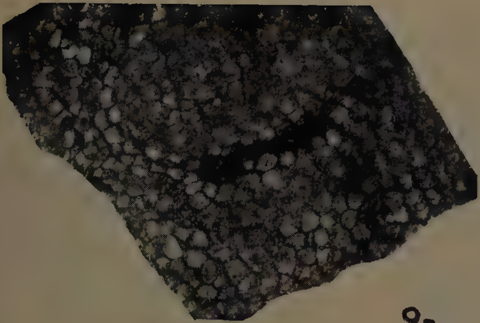
Fig. 10. *Tryplasma brevikense* sp. nov. Pal. Mus. Oslo 8532 or 3, Encrinite Limestone, Quarry at Skjellbukta, Frierfjorden, 10a, trans. section × 2; 10b oblique. section × 2.

Fig. 11. *Tryplasma brevikense* sp. nov. 64954, Encrinite Limestone, Skjellbukta, Frierfjorden, 11a, trans. section × 2, 11b, vert. section × 2.

Fig. 12. *Eofletcheria irregularis* sp. nov. Holotype, Pal. Mus. Oslo 66261, Encrinite Limestone, north side of Skjellbukta, Frierfjorden, × 2.

Fig. 13. *Eofletcheria ?irregularis* sp. nov. Pal. Mus. Oslo 8534, Encrinite Limestone, Quarry at Skjellbukta, Frierfjorden, × 2.

PLATE 2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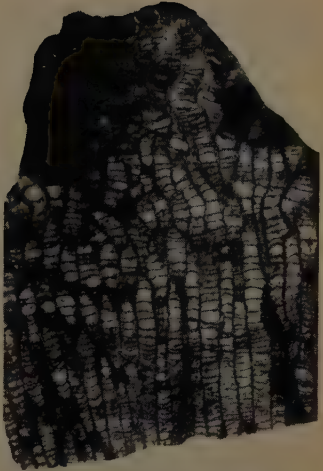
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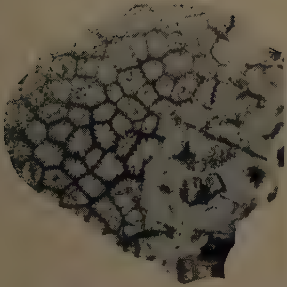
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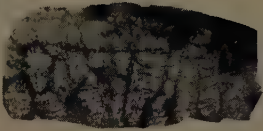
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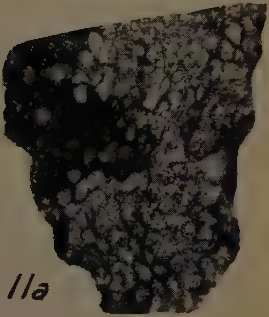
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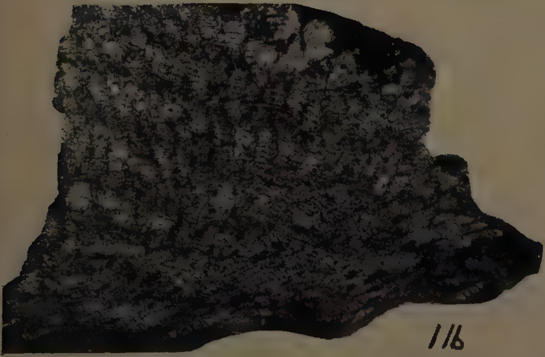
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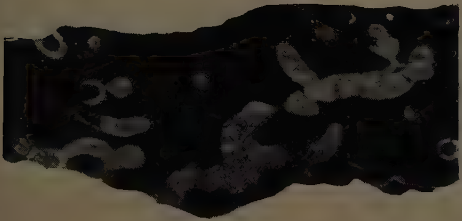
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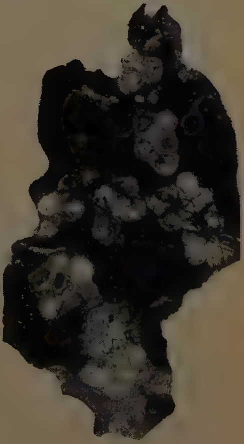
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Plate 3.

Fig. 14. *Eofletcheria irregularis* sp. nov. Pal. Mus. 8536, Encrinite Limestone, Quarry at Skjellbukta, Frierfjorden, × 2.

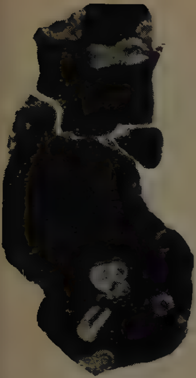
Fig. 15. *Eofletcheria subparallela* sp. nov. Pal. Mus. Oslo 66293, considered to be fragment of holotype 66294, Mjøsa Limestone, Loddvik, Helgøya, Mjøsa; 15a trans. section, × 2, 15b vert. section × 2.

Fig. 16. *Eoflectheria subparallela* sp. nov. trans. section prepared by or for Kiær, probably from the holotype, × 2.

Fig. 17. *Eofletcheria subparallela* sp. nov., Pal. Mus. Oslo 38476, Mjøsa Limestone, Quarry south of Bergvik, Helgøya, Mjøsa; 17a trans. section, × 2 17b, vert. section × 2.

Fig. 18. *Eofletcheria ?subparallela* sp. nov., Pal. Mus. Oslo 66286, Mjøsa Limestone, railroad cut north of Eina station, Toten; 18a trans. section, × 2, 18b vert. section × 2.

PLATE 3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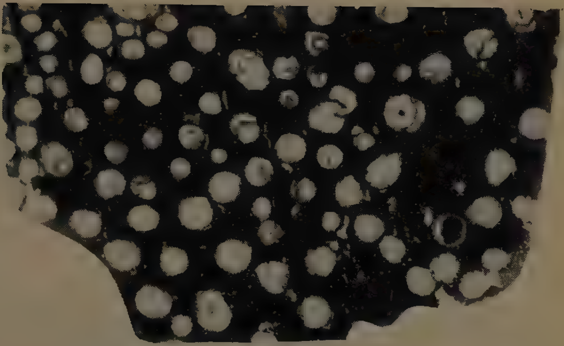
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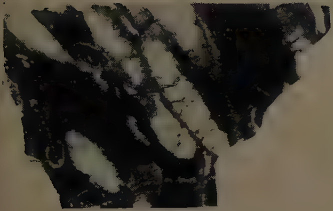
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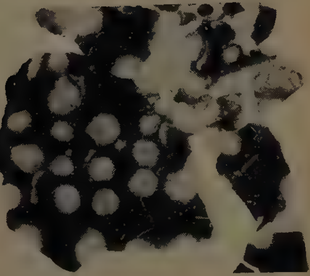
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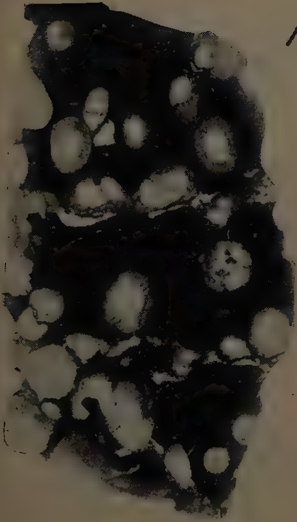
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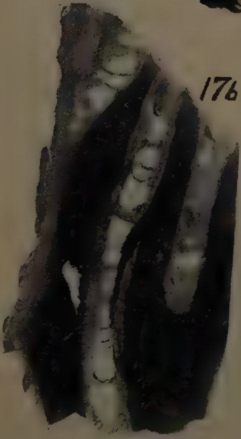
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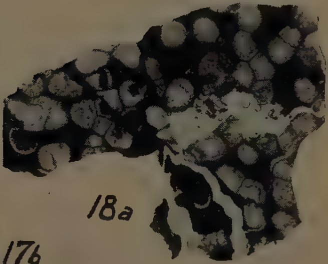
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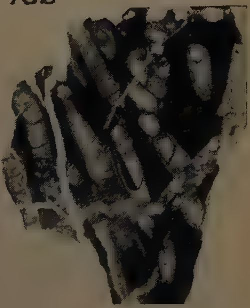
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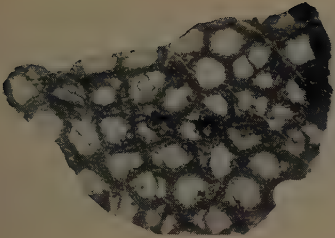
Plate 4.

Fig. 19. *Liopora favosa* (McCoy). Sections figured by Kiær, 1930, pl. III; Mjøsa Limestone, Helgøya, × 2.

Fig. 20. *Liopora favosa* (McCoy). Pal. Mus. Oslo 66273, Mjøsa Limestone, Nordre odde, Bergvik, Helgøya, Mjøsa; 20a trans. section × 2. 20b vert. section × 2.

Fig. 21. *Liopora favosa* (McCoy). Pal. Mus. Oslo 66266, Mjøsa Limestone, Bergvik, vert. section × 2.

Fig. 22. *Liopora favosa* (McCoy). Pal. Mus. Oslo 66270, Mjøsa Limestone, Quarry south of Bergvik, Helgøya, Mjøsa; 22a trans. section × 2,22b vert. section × 2.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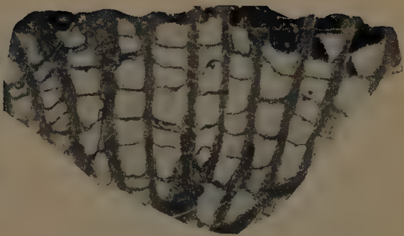
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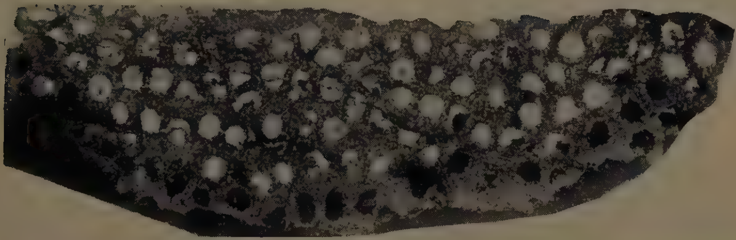
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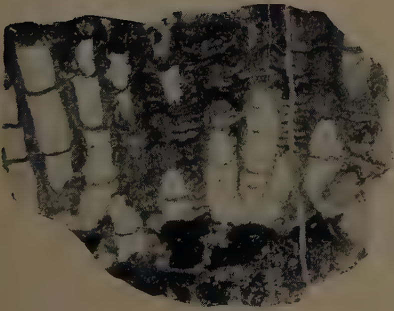
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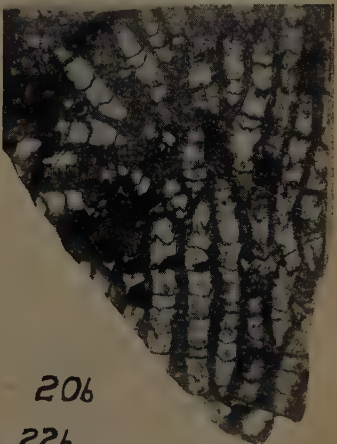
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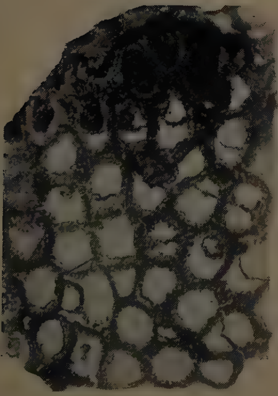
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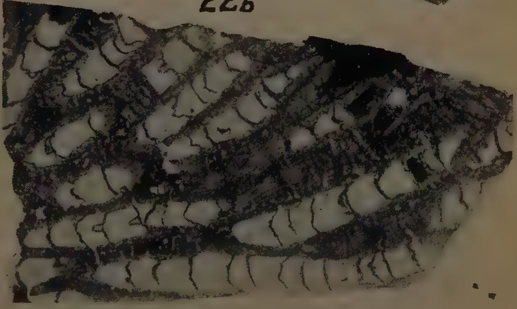

22b

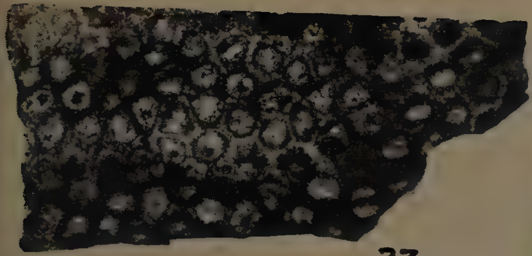
Plate 5.

Fig. 23. *Liopora tenuis* sp. nov. Holotype, Pal. Mus. Oslo 8529, Encrinite Limestone quarry at Skjellbukta, Frierfjorden, 23a trans. section, × 2, 23b vert. section × 2.

Fig. 24. *Nyctopora* aff. *parvotubulata* Kiær. Pal. Mus. Oslo 66265, Mjøsa Limestone, Loddvik, Helgøya, Mjøsa. 24a trans. section × 2, 24b oblique section × 2.

Fig. 25. *Coccoseris tumulosus* sp. nov. Holotype, Pal. Mus. Oslo 66260, Encrinite Limestone, north side of Skjellbukta, Frierfjorden, 25a b, × 2; 25c one corallite in trans. section. × 60.

Fig. 26. *Reuschia aperta* Kiær. Lectotype, Pal. Mus. Oslo 32434. Vikenes, Stord, Norway; 26a trans. section ca. × 2, 26b and c vertical and tangential section ca. × 2.



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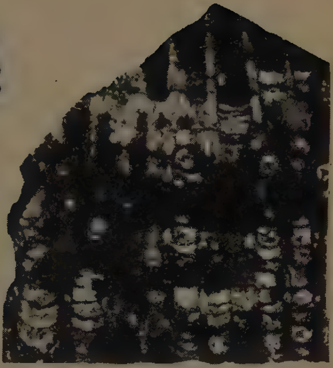

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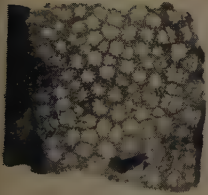

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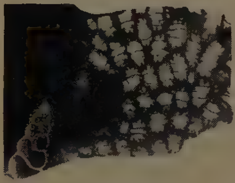

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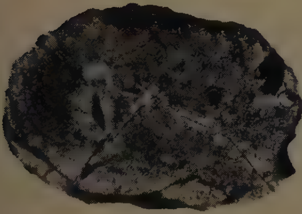

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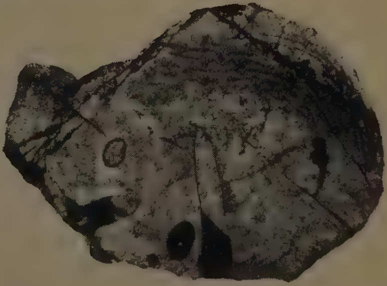

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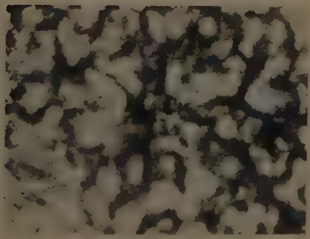

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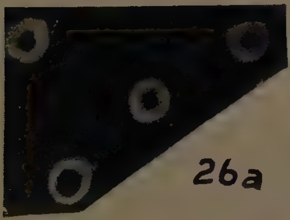
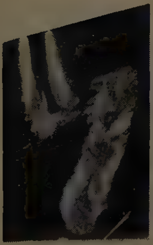


26a



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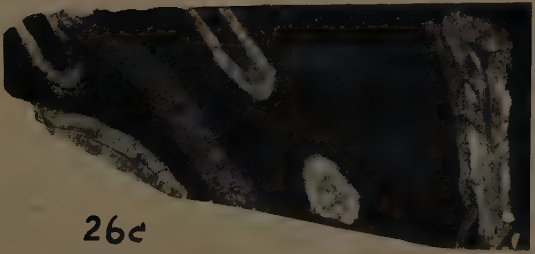


26c

THE MIDDLE ORDOVICIAN OF THE OSLO REGION, NORWAY

3. Graptolites dating the Beds below the Middle Ordovician.

BY

NILS SPJELDNÆS

Abstract. The lower part of the zone of *Didymograptus hirundo*, zone 3b ε has been found, forming the upper part of the Lower *Didymograptus* Shale (3b) at Slemmestad, SSW of Oslo. The development of *D. hirundo* and some *Isograptus* species is briefly discussed. A number of biserial graptolites are described from zone 3b ε. The stratigraphical importance of the occurrence of *D. hirundo* is mentioned.

Introduction.

The fossils mentioned in this note were found during the author's studies of the transitional beds between the Lower *Didymograptus* Shale and the *Orthoceras* Limestone (3c). During a visit to the "Old Quarry" at Slemmestad the author found *Isograptus gibberulus*, and professor L. Störmer therefore adviced me to study in detail the stratigraphy of the layers yielding this species. The specimens of *Didymograptus hirundo* reported from this locality by MONSEN (1937, p. 120) were also studied in order to ascertain that strata corresponding to the zone of *Did. hirundo* occur below the *Orthoceras* Limestone at this locality.

During these studies, a number of biserial graptolites were found, most of them in the upper layers at Slemmestad, but also in other localities, and in the collections of Paleontologisk Museum, Oslo. Beside the badly preserved *Glossograptus ?* sp. reported by MONSEN (1937, p. 217), biserial graptolites of this age were unknown in Norway.

In Great Britain, biserial graptolites are met with in still older layers, in the middle part of the zone of *Did. extensus*. The stratigraphical value of the biserial graptolites described in this note are none, at least for the present.

Description of localities.

The old quarry at Slemmestad is a part of a syncline running SW—NE. The *Orthoceras* Limestone was quarried in the southern part of the syncline, so that now the underlying Lower *Didymograptus* Shale is well exposed. The sections are chiefly along the bedding planes, which are intensively jointed, disected by a diabase dike, some N—S faults and a number of flexure-like zones of disturbance. The measurements of thickness are therefore approximative, because it is difficult to judge the vertical displacement along the flexures. It seems, however, to be of the order of size of less than 1/2 m.

The profile found at this locality is, from the top:

Orthoceras Limestone, with phosphatic band at the base.

0—1 m. Grey mudstones with conchoidal fracture and some small ellipsoidal marl lanses. A few streaks of dark grey shale with graptolites (Layer I) occur near the base.
1—2 m. Banded grey and dark shale. Graptolite layer II in the lower part.
2—3 m. Dominating dark grey shale with some lighter bands. Graptolite layer III in the lowest part.
3—4,5 m Black shale with pyrite concretions.

below 4,5 m, zone of *Phyllograptus angustifolius elongatus*, 3b δ. Most of the graptolites are found in the black or dark grey shale.

The following graptolites were met with: From Layer I: *Hallograptus mucronatus inutilis*, *Did. hirundo*, *Did. slemmestadi*.

From Layer II: *Orthograptus ?* sp., *Glossograptus* aff. *acanthus*, *Hallograptus* sp., *Phyllograptus* sp., *Tetragraptus* aff. *bigsbyi*, *Isograptus gibberulus*, *Did. hirundo*, *Did. slemmestadi*.

From Layer III: *Orthograptus ?* sp., *Trochograptus diffusus*, *Phyllograptus* cf. *nobilis*. *Isograptus lunata*, *Did. hirundo*, *Did. slemmestadi*, and in the upper part probably also *Glossograptus* aff. *acanthus* and *Glyptograptus* aff. *dentatus*.

Just below this layer one finds *Phyllograptus angustifolius elongatus* (not so large and numerous as lower down), *Phyllograptus* cf. *illicifolius, Isograptus norvegicus, Did. patulus/hirundo,* and *Tetragraptus bigsbyi askerensis.*

Beside the graptolites, only some inarticulate brachiopods have been found.

The graptolites mentioned in the above lists are the typical forms only, the whole fauna comprizes a large number of other forms, among them a 6-branched *Dichograptus* with broad branches and some other many-branched forms, a large number of extensiform and a few pendant *Didymograptus* species.

At another locality, the bus stop "Toern", about 500 m NNE of the old quarry, the following graptolites were found in a black shale 1 m. below the *Orthoceras* Limestone: *Hallograptus* aff. *mucronatus inutilis, Did. hirundo,* and *Did. slemmestadi.* Also at S. Bjerkåsholmen, north of Slemmestad, indeterminable biserial graptolites were found just below the *Orthoceras* Limestone.

The *Did. hirundo* zone is met with also in other parts of the Oslo District. At Rikshospitalet in the City of Oslo *Did. hirundo* occurs about 1. m. below the *Orthoceras* Limestone. 2 m. below the limestone one finds *Isograptus norvegicus* and *Isograptus lunata ?,* together with *Did. protobifidus* and other pendant Didymograpti.

At Huk, Bygdøy, Oslo, *Glossograptus* sp., *Did. slemmestadi* and badly preserved broad Didymograpti like *patulus/hirundo* are found 0,2 m below the *Orthoceras* Limestone.

The quantitative distribution of the species is very different in the different localities. At Slemmestad rather large forms with broad branches dominate, but in other places, such as in the City of Oslo, smaller forms are abundant. At Rikshospitalet, for instance, delicate pendant Didymograptids are dominating, whereas Phyllograpti, *Did. hirundo* and other large species are quite rare.

Description of fossils.

Isograptus gibberulus NICHOLSON, 1875.

Pl. 1, fig. 5. Text fig. 1 E.

In the Norwegian Lower *Didymograptus* Shale this species seems to form the end of a continuous series of development. Typical specimens are found in Layer II in the old quarry at Slemmestad.

These specimens agree well with those described by BULMAN (1933) from Sweden, and differ from the older *I. norvegicus* MONSEN in having all thecae overlapping, also the proximal ones. The thecae are also notably longer in *I. gibberulus*.

This species was reported from two Norwegian localities by MONSEN, (1937, p. 155); Bratland (Gausdal) and Modum (western part of the Oslo Region). No specimens from Modum are, however, preserved in the collections of Paleontologisk Museum, Oslo, whereas the holotype and several other specimens of *I. norvegicus* are from that locality.

Isograptus norvegicus MONSEN, 1937.

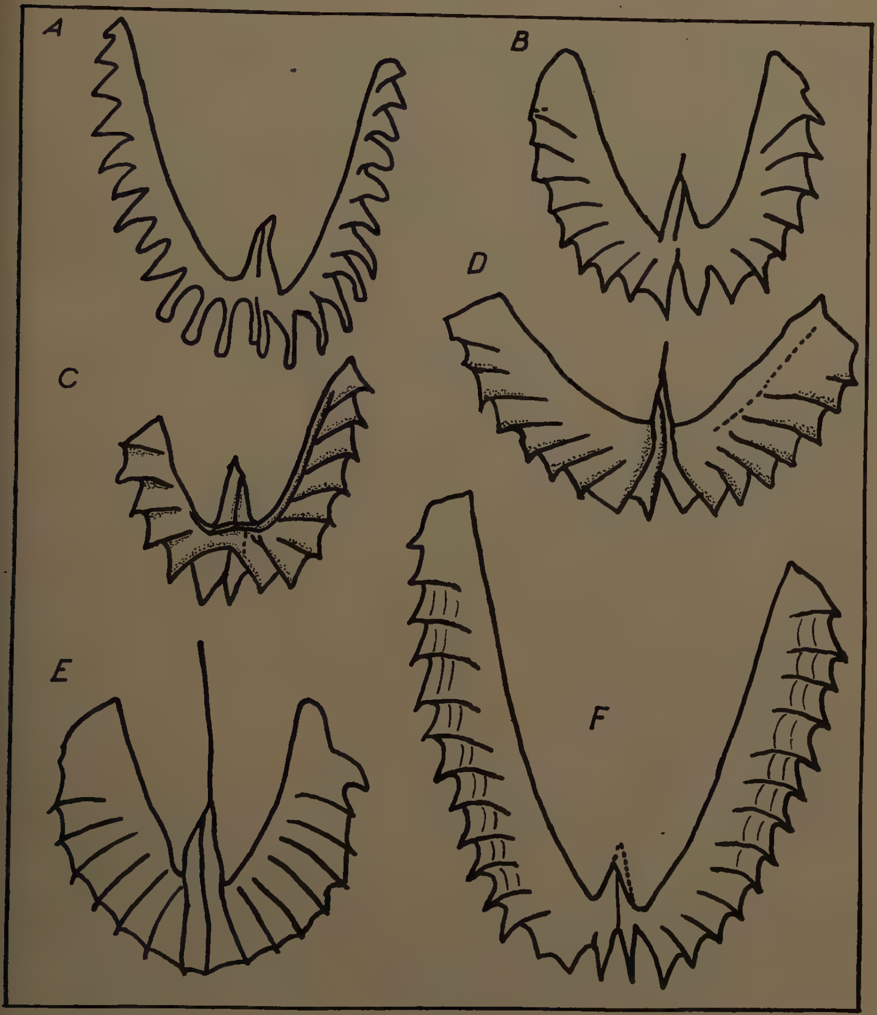
Pl. 1, figs. 2, 4. Text figs. 1 B, C, F.

1937 *Isograptus caduceus norvegicus* (parte) — MONSEN, 1937, p. 154, pl. 5, figs. 5, 12, 14, 18, not 17!

This species differs from *I. gibberulus* in having the thecae less overlapping, so that up to 1/4 of the thecae are free. In the proximal part, some of the thecae are free all their length, at least at one side, forming one or more slits in the lowest part of the rhabdosome.

The holotype of this species (MONSEN, 1937, pl. 5, fig. 18; this paper, pl. 1, fig. 6 and text fig. 1 F) is rather peculiar in being like a *Tetragraptus* of the *bigsbyi* type, in which only two branches are preserved. It differs from the other specimens from the same locality in the uneven curvature of the distal part of the branches, and in the rapid increase of the thickness of the branches. The sicula is not preserved, so the budding can not be studied in detail. It is possible that this specimen represent another species than the other ones, but the present material is too small to permit a further splitting of this species.

The holotype may also represent a primitive form, having several slits between the thecae in the proximal part. The younger specimens, from the zone of *Phyllograptus angustifolius elongatus*, have only one slit (between the sicula and thecae 1^1), which is gradually reduced in the transitional forms between this species and *I. gibberulus*. If the specimens are not well preserved, it may be difficult to discriminate between the primitive forms of this species and Tetragrapti of the *bigsbyi* type, especially *Tetragraptus bigsbyi askerensis* MONSEN, in which the thecae of the proximal part is more vertical than usual, and somewhat overlapping (cf. MONSEN 1937, p. 170).



Textfig. 1 Development of the Norwegian Isograpti.

A *Isograptus spinosus* sp. n. Ensjö, Oslo, zone 3bγ. Specimen no. K 0931.
B *Isograptus norvegicus* MONSEN, Modum, zone 3 bδ. Specimen no. K 0909.
C *Isograptus norvegicus* MONSEN, Stensberggata, Oslo, zone 3 bδ. Specimen nr. K 0904.
D *Isograptus lunata* HARRIS, Old quarry, Slemmestad, zone 3b ε, lower part of Layer III.
E *Isograptus gibberulus* NICHOLSON, old quarry, Slemmestad, zone 3b ε, Layer II.
F *Isograptus norvegicus* MONSEN, holotype, from Modum, zone 3b δ. Specimen no. K 0225.

The specimens shown is this figure are also found in plate 1, as unretouched photographs. Figs. A, B, C, and F are figured by MONSEN (1937).

All figures are 6 times enlarged.

It is probable that the intermediate forms between *norvegicus* and *gibberulus* could be given specific or subspecific names, but at present this seem unadviceable, because the present material is too small to show the limits of variation, and because a detailed comparition may show that some of the names given to early varieties of *Isograptus* by HARRIS (1933) from Australia (and by RUEDEMAN 1906 from U.S.A.) may be applied to the Norwegian forms as well.

Isograptus lunata HARRIS, 1933.

Pl. 1, fig. 3. Text fig 1 D.

1933 *Isograptus caduceus* var. *lunata* — HARRIS 1933, p. 90, text figs. 3—6.

This species is common in Layer III at Slemmestad, and it is also found at a corresponding or somewhat lower level in the City of Oslo. It was first believed to be a transitional form between *norvegicus* and *gibberulus*, but further collecting of a large number of specimens showed that this species has some constant features, which separates it from the two other species. There is no overlap in the limits of variation within the two groups.

The diagnostic feature is the angle of divergence of the branches, which is more than 90° in *lunata*, and much less in the two other species. The limits of variations is very small within the two groups, even when a large number of specimens have been measured. The sicula is also smaller in *lunata* than in the two other species. The development of the thecae is like that of the transitional forms between *norvegicus* and *gibberulus*, with all the thecae fused, except the sicula and 1^1.

Since *norvegicus* and *gibberulus* are connected with a continuous series of intermediate stages, all with approximately the same angle of divergence, it seems advicable to regard *I. lunata* as a separate species, and not only as a subspecies as done by HARRIS, 1933.

The Australian forms seem to have a wider variation than the Norwegian ones as regards the angle of divergence, but this may be due to compression of some of the Australian specimens. Further studies may show that the Norwegian form is a separate species or subspecies.

Isograptus spinosus sp. n.

Pl. 1, fig. 1. Text fig. 1 A.

1933 *Isograptus caduceus norvegicus* (parte) — MONSEN, 1937, pp. 154, 241—242, pl. 5, fig. 17.

Holotype: No. K 0931, Paleontologisk Museum, Oslo.

Type locality and horizon: Ensjö, city of Oslo, zone of *Phyllograptus densus* (3 b γ) (in MONSEN 1937, explanation to plate 5, by an error *Ph. angustifolius elongatus*).

Diagnosis: *Isograptus* with practically no overlap of the thecae in the proximal part, and only slight overlap in the extreme distal parts, so that the thecae form long spines.

In this species nearly all the thecae are free, but here also the tendency to increase in overlapping of the thecae in the distal parts is seen. The even curvature of the upper margin is found in this species just as in the younger ones. It has to be mentioned that even this species has, as far as can be judged, and isograptid type of budding. This is indicated by the steepness of the proximal thecae

This species is apparently the oldest one of the genus described till now, and the conditions of the thecae may therefore be regarded as primitive. The overlapping thecae appearing in the distal ends of the branches mark the development of this line, which in Norway ends with *I. gibberulus*. If *Isograptus spinosus* is accepted as a primitive *Isograptus*, this will exclude the Tetragrapti of the *bigsbyi* type as the ancestors of *Isograptus*.

The dimensions and angles of the *Isograptus* species described here are shown in Table I; the development of the rhabdosomes in plate 1, and the degree of overlapping of the thecae in text fig. 1.

TABLE I.

Species	Max. width.	Slits in prox. part	Thecae in 10 mm	Zone in Norway
gibberulus	7 mm	none	15—16	3bε
lunata	10	1	16	3bε
norvegicus	7 (10)	1—3	13—14	3bδ
spinosus	6	several	16	3bγ

In Australia HARRIS (1933) described the development of the Isograpti. The present material seems to form only a small part of the rich phylogenetic series described by that author. Some small differences seem to occur between the two areas, the important being that the Norwegian species show no increase in size, and that the younger forms have not been observed in Norway.

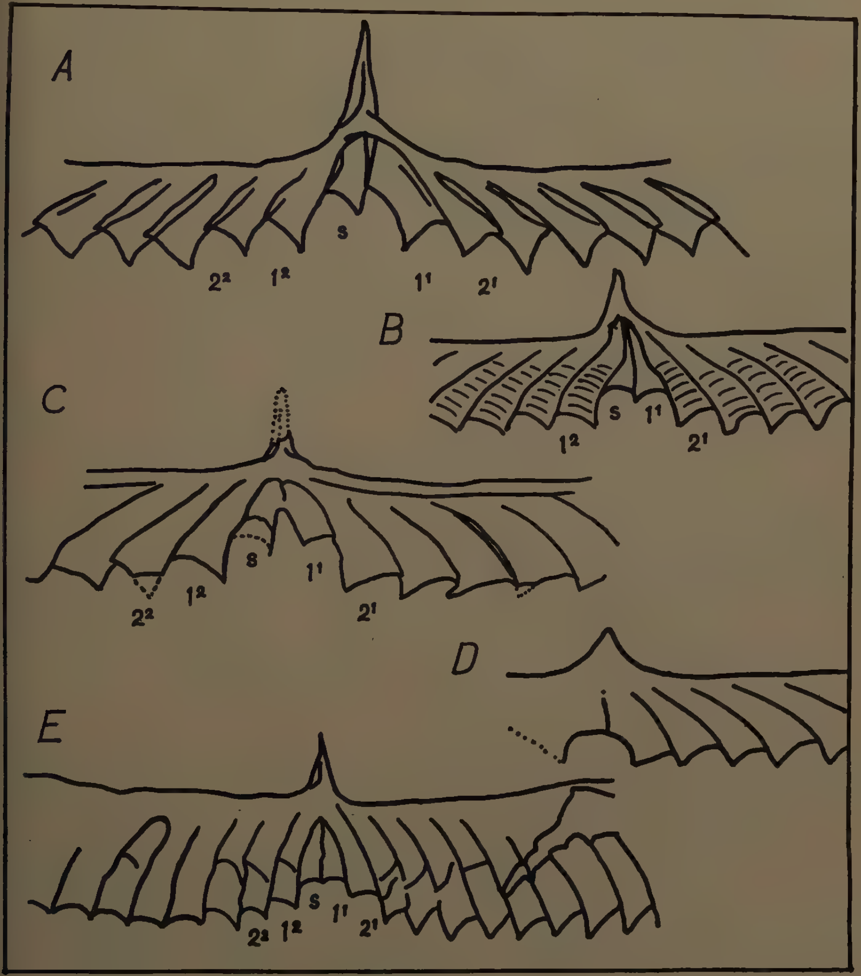
Isograptus norvegicus seems to correspond to *I. caduceus primula* HARRIS but is larger. *I. spinosus* may be a transitional form between *Didymograptus eocaduceus* HARRIS, and the younger Isograpti. *D. eocaduceus* was suggested to be one of the ancestors of *Isograptus* by HARRIS (1933, p. 98) who, however, lacked intermediate forms. A specimen which was referred to *D. eocaduceus* with some doubt was reported by MONSEN (1937, p. 242) from the same zone and locality as the holotype of *I. spinosus*. It is therefore possible that the early development of the Isograpti are better known from Norway than from Australia. On the other hand, the later part of the developmental series is not found in Norway, probably because of the change of facies. In Great Britain and Sweden, this developmental series is unknown, the only species described in detail is the typical *I. gibberulus*. Other forms are, however, probably present.

Didymograptus hirundo SALTER, 1863.

Text figs. 2 B—E

The development of this species from *D. extensus* and *D. nitidus* has been thoroughly described by BULMAN (1936) and ELLES (1933). A large number of transitional forms are met with in this series, which seems to be continuous. The specimens found at Slemmestad belong as far as the proximal part is known to the "lower" types of *hirundo*, or to transitional forms between *patulus* TÖRNQUIST and *hirundo*. The youngest specimens from which the proximal part is known are, however, from the lower part of Layer III, and the fragmentary specimens met with in the higher layers have broader branches with the thecae directed more straightly downwards (Table II). It is therefore highly probable that they representent the typical *hirundo*. The proximal part of a specimen from Layer III and the layers just below are shown in text fig. 2 (B, D).

The only difference between the Norwegian and the British specimens is that the thecae 1^2 and 2^1 are not fused below the crossing canals in the Norwegian specimens, which in this feature are more like *Did. patulus* (text fig. 2 A). On the other hand the sicula and



Textfig. 2 Development of *Didymograptus hirundo.*

A *Did. patulus* TÖRNQVIST, zone of *Isograptus gibberulus,* Scania, Sweden.

B *Did. hirundo/patulus?,* zone 3bε, just below Layer III, Old quarry, Slemmestad specimen no. K 0916—K 0917.

C *Did. hirundo,* narrow form, Basal portion of *D. hirundo* zone, Shropshire.

D *Did. hirundo.* zone 3bε, Layer III, the youngest specimen with proximal part in the author's material.

E *Did. hirundo,* typical (somewhat laterally compressed) Zone of *D. hirundo* North Wales.

Figs. A, C, E, are from BULMAN; 1938, text fig. 29. The specimen shown in fig. B is figured by MONSEN, 1937 (pl. 15, figs. 8, 12).

All figures are 5 times enlarged.

TABLE II.

Specimen from layer	Width of branches	Thecae in 10 mm	Angle og thecae	Depth of sicular slit[1]
below III	2,8 mm	13	60°	0,6 mm
III	3,1	12	60°	0,4
top of III	3,7	11	75—80°	—
I	4,1	11	85—90°	—

thecae 1^1 are fused in the Norwegian specimens, as in the typical *hirundo* from Great Britain.

Glyptograptus aff. *dentatus* (Brogniart, 1828).

Pl. 1, figs. 12—13.

Three specimens probably belonging to this species have been found. Two are from the upper part of zone 3b δ. They are from the same slab as *Glossograptus* sp. figured by Monsen (1937, pl. 11 fig. 1). These two specimens have 11 thecae in 10 mm (*G. dentatus* has according to Elles & Wood 18 to 12); the maximal length is 26 mm (fragmentary) and they are 4 mm broad (2 mm for *G. dentatus*). The proximal part is not found, and the state of preservation is not good. The specimens can therefore not be determined safely. They belong probably to a new species, but the material present is, however, much too meagre for a safe specific determination.

The third specimen is from Stensberggata (City of Oslo) cf. Monsen (1937, p. 67). It is 20 mm long, 2,5 mm broad and has 11 thecae in 10 mm. On the same slab are found *Tetragraptus* cf. *bigsbyi* and an extensiform *Didymograptus* quite like *D. slemmestadi*. It is therefore highly probable that the specimen comes from approximately the same horizon as the two other specimens. This one is smaller than the two others and may belong to another species, probably to *G. dentatus* itself. The bad state of preservation and the lack of the proximal part makes, however, the indentification of the species uncertain.

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[1] The distance between aperture of the sicula and a line drawn through the apertures of the adjoining thecae.

Orthograptus ? sp.

Pl. 1, fig. 11.

This peculiar species is quite common in Layers II and III in the profile described from Slemmestad, but only fragments have been found till now. The maximal length observed is 11 mm, and the width is 2—2,5 mm. The thecae are of a simple Dichograptid type, and 12 of them are found in 10 mm. The angle between them and the pronounced median septum is 35—40°. No proximal part was found.

According to BULMAN (1938, pp. D29, D57) only some few genera of biserial graptolites with Dichograptid thecae are known; *Orthograptus* (and *Petalograptus*) and *Cardiograptus*. The present species differs from *Orthograptus* in having no spines, and from *Cardiograptus* in the shape of the rhabdosome, which is slender parallel-edged in this species and leaf-shaped in *Cardiograptus*. Because the proximal part is not known, it is impossible to settle its generic position. Provisionally it is included in *Orthograptus*.

Hallograptus aff. *mucronatus inutilis* (HALL, 1865).

Pl. 1, fig. 8.

This form is common in Layers I and II in the profile described from Slemmestad. The specimens from Layer I, which are the best preserved ones, are quite like *Hallograptus mucronatus inutilis* (HALL) cf. ELLES & WOOD (1901, p. 332), but are somewhat longer, max. length 20 mm (incomplete) (*inutilis* max 15 mm). Width 2—2,5 mm. (= *inutilis*). 12 thecae are found in 10 mm, as in *inutilis*.

In Great Britain, *Hallograptus mucronatus inutilis* is reported from the zones of *Did. extensus* and *Did. bifidus*.

Glossograptus aff. *acanthus* ELLES & WOOD.

Pl. 1 fig. 7.

This form is common in layer II at Slemmestad. It is rather like *Hallograptus* aff. *mucronatus inutilis* in the shape of the thecae, but differs from that species in the subfusiform rhabdosomme. Length 19 mm. (According to ELLES & WOOD 1901, p. 314, more than 25 mm.) Width 4 mm (= *acanthus*). 14 thecae in 10 mm (10 according to ELLES & WOOD). ELLES & WOOD says: ”The subfusiform shape of the polypary and the disposition of the spines give to this species a more Phyllograptoid appearance than of any of its British congeners". In fact the Norwegian specimens show a marked thickening in the central part of the rhabdosome, and in some cases apparently a double row of thecae as if the species was a *Phyllograptus* with glossograptoid thecae. According to BULMAN (1938, p. D58, Table II) the Glossograpti have descended from *Phyllograptus*, and the precent species seems to be an intermediate form or a very early type of *Glossograptus*.

Glossograptus acanthus is reported from the zones of *Did. extensus* and *Did. bifidus*. in Great Britain.

Phyllograptus cf. *nobilis* HARRIS & KEBLE, 1932.

Pl. 1, figs. 9—10.

A species of *Phyllograptus* is met with in Layers II and III at Slemmestad, in which the thecae are not in contact for quite their full length, and the thecal walls have the sigmoidal curvature characteristic of this species (cf. EKSTRÖM, 1937, p. 34—35 pl. 6, figs. 22—25). All the normal-sized specimens of this species are, however, badly preserved, and some of the features mentioned may to a certain degree be due to compression and distortion. Pl. 1 fig. 10 shows a small specimen, probably belonging to this species, in which the free thecae are especially well seen.

Stratigraphical Conclusion.

STÖRMER (1952) has called the uppermost part of the Lower *Didymograptus* Shale zone 3b ε. This zone, as defined here, comprizes the uppermost 4,5 m (including the layers with *Trochograptus diffusus*) in the Slemmestad District, the only place in the Oslo Region where this zone has as yet been thoroughly studied. It corresponds to the lower part of the zone of *D. hirundo* in Great Britain.

It seems as if the *hirundo* zone in Great Britain is not much larger than one of the subzones in the *extensus* zone, and should rather be compared with them in thickness and duration than with the whole *extensus* zone (cf. ELLES, 1933, p. 96—97). *Isograptus gibberulus* seems to occur earlier in Great Britain than in Norway, where the typical *I. gibberulus* is not met with till in the lower part of the *hirundo* zone, whereas it seems to occur already together with *nitidus-patulus-praenuntius* types in Great Britain. The same is probably true in Sweden, where the zone of *Isograptus gibberulus* corresponds to both zone 3b δ and 3b γ in Norway (cf. MONSEN 1937, p. 226).

The fauna of the *hirundo* zone at Slemmestad (old Quarry) is peculiar in being dominated by biserial graptolites. This may perhaps have some connection with the lithology of the sediment (banded shale, indicating relatively rapid changes in hydrology). At "Toern", Slemmestad, the *hirundo* zone is represented by black shales, and here the extensiform Didymograptids are dominating.

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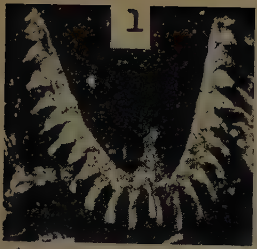
Manuscript received June 6, 1952.

Explanation to Plate I.

1) *Isograptus spinosus* sp. n. Holotype. From Ensjö, Oslo. Zone 3bγ, of *Phyllograptus densus*) Specimen nr. K 0931. Type to MONSEN 1937, Pl. 5 fig. 17. 4 x.
2) *Isograptus norvegicus* MONSEN. From Modum. Zone 3bδ, of *Phyllograptus angustifolius elongatus*. Specimen nr. K 0909. Type to MONSEN 1937, pl. 5, fig. 12. 4 x.
3) *Isograptus lunata* HARRIS, From the old quarry, Slemmestad. Zone 3bε of *Didymograptus hirundo* (lowest part). 4 x.
4) *Isograptus norvegicus* MONSEN. From Stensberggt. Oslo. Zone 3bδ, of *Phyllograptus angustifolius elongatus*. Specimen nr. K 0904. Type to MONSEN 1937, pl. 5, fig. 14. 4 x.
5) *Isograptus gibberulus* (NICHOLSON) From the old quarry, Slemmestad. Zone 3bε, of *Didymograptus hirundo* 4 x.
6) *Isograptus norvegicus* MONSEN. Holotype. From Modum. Zone 3bδ, of *Phyllograptus angustifolius elongatus*. Specimen nr. K 0225. Type to MONSEN 1937 pl. 5, fig. 18. 4 x.
7) *Glossograptus* aff. *acanthus* ELLES & WOOD. From the old quarry, Slemmestad. Zone of *Didymograptus hirundo*, 3bε. 4 x.
8) *Hallograptus* aff. *mucronatus inutilis* (HALL) From the old quarry, Slemmestad. Zone 3bε, of *Didymograptus hirundo*. 4 x.
9) *Phyllograptus* cf. *nobilis* HARRIS & KEBLE. From the old quarry, Slemmestad. Zone 3bε, of *Didymograptus hirundo*. 2 x.
10) *Phyllograptus* cf. *nobilis*. Small specimen probably belonging to this species. From the old quarry, Slemmestad. Zone 3bε, of *Didymograptus hirundo*. 4 x.
11) *Orthograptus ?* sp. Specimen with distal end preserved. From the old quarry, Slemmestad. Zone 3bε, of *Didymograptus hirundo*. 4 x.
12) *Glyptograptus* aff. *dentatus* (BROGNIART) Large type. From the old quarry, Slemmestad. Zone 3bε, of *Didymograptus hirundo*. Specimen nr. 40755. 2 x.
13) *Glyptograptus* aff. *dentatus* (BROGNIART) Smaller type. From Stensberggt. Oslo. Zone 3bδ?, of *Phyllograptus angustifolius elongatus ?* 2 x.

PLATE 1

1



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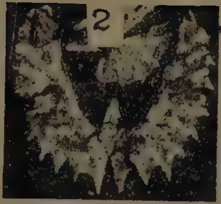

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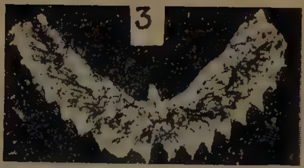

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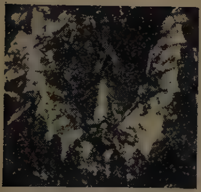

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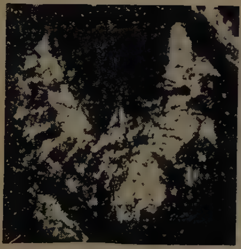

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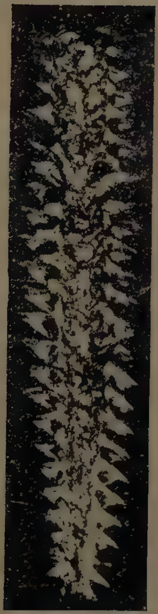

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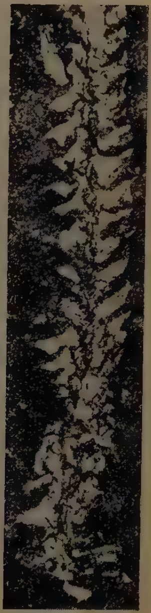

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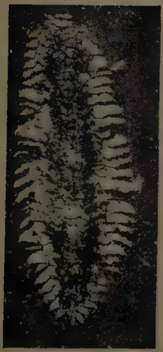

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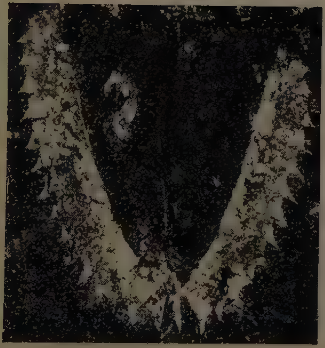

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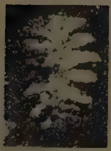

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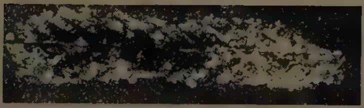

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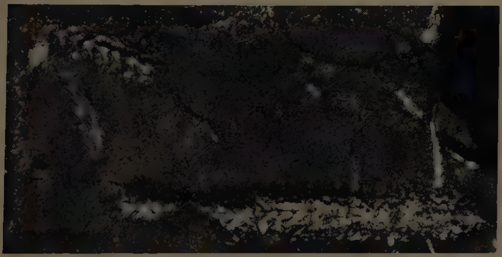

CLASSIFICATION OF PALEOZOIC STRAIGHT-HINGED OSTRACODS

BY

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University of Oslo, Oslo 45, Norway)

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Abstract. The straight-hinged Paleozoic ostracods are assigned to the new suborder Paleocopa (superfamilies Beyrichiacea and Leperditiacea) and the suborder Podocopa (family Quasillitidae). New taxonomic units are: family Sigmoopsiidae, subfamilies Sigmoopsiinae, Glossopsiinae, Beyrichiopsiinae, Conchoprimitiinae, Eridoconchinae, and the genera *Sigmoopsis*, *Sigmobolbina*, *Carinobolbina*, *Bolbina*, and *Hesslandella*. In the classification of the Beyrichiacea more attention is paid to type of dimorphism, submarginal structure (velate and carinal structures), and unusual features than to the degree of sulcation and lobation. Probable phylogenetic lines from trisulcate to unisulcate forms suggest that trisulcate forms need not be more advanced than uniculcate forms. Moult retention is described in the Conchoprimitiinae, and its bearing on the study of ontogeny and determination of orientation is discussed. The proposed classification of straight-backed Paleozoic ostracods is presented in a list (p. 266). A range chart (p. 276) shows the stratigraphical distribution of the families and subfamilies. The Healdiidae and Thlipsuridae are believed to be related to straight-hinged Podocopa (Quasillitidae). The relationships of the Paleocopa to other ostracod suborders are still uncertain.

Acknowledgements.

During the preparation of this paper the writer has had the privilege of studying material of Paleozoic ostracods at two Swedish and three British institutions, and takes this chance of expressing his gratitude to Prof., Dr. P. Thorslund and Dr. I. Hessland (Paleontological Museum, University of Uppsala), Prof., Dr. E. Stensiö and Dr. T. Ørvig (Swedish State Museum of Natural History, Stockholm), Prof., Dr. W. B. R. King and Mr. A. G. Brighton (Sedgwick Museum, Cambridge), Dr. C. J. Stubblefield (Geological Survey & Museum, London), and Mr. R. Baker (British Museum, Natural History, London)

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Suborder Paleocopa nov.

Diagnosis: — Shell without frontal opening. Hinge line straight and usually long. Apparently no calcareous inner lamella. There is a tendency to develop lobes and sulci, and submarginal ridges. Animal unknown.

Remarks: — It is regrettable that the animal is unknown, so that the diagnosis cannot be fully compared with those of recent suborders. Even in recent suborders, however, features of the shell are given considerable diagnostic importance. The new suborder Paleocopa constitutes such a large and well-defined group, that it may well be recognized even if it should prove to be close to one or another of recent suborders. The suborder Paleocopa embraces the two superfamilies Beyrichiacea and Leperditiacea.

SUPERFAMILY BEYRICHIACEA ULRICH & BASSLER, 1923.

Diagnosis: — See p. 262. *Included families:* — See list p. 266.

Terminology.

Beyrichiacean ostracods may be rather smoothly convex, but usually the surface of the valves consists of inflations and depressions. As pointed out by Schmidt (1941, p. 15), there are two types of terms for describing the features of the ostracod carapace, namely those which denote the type of structural elements (may be called general terms) and those which denote structural elements whose type may vary, but whose position in the carapace is determined (may be called special terms).

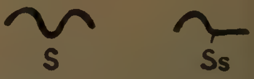


Fig. 1. The difference between sulcus (S) and semisulcus (Ss).

General terms are such as lobe, sulcus, ridge, frill, etc. The terminology used here follows that of Kesling (1951b), except for the introduction of the term *semisulcus*. The term is illustrated in text figure 1. Whereas a sulcus lies between two inflations, the semisulcus is only bordered on one side by an inflation. Usually a semisulcus is not considered as a sulcus. *Rigidella mitis* was described by Öpik (1935, p. 11) as being typically trilobate, and by Hessland (1949, p. 339) as being distinctly tetralobate. This species has four lobes, separated by two sulci and a semisulcus.

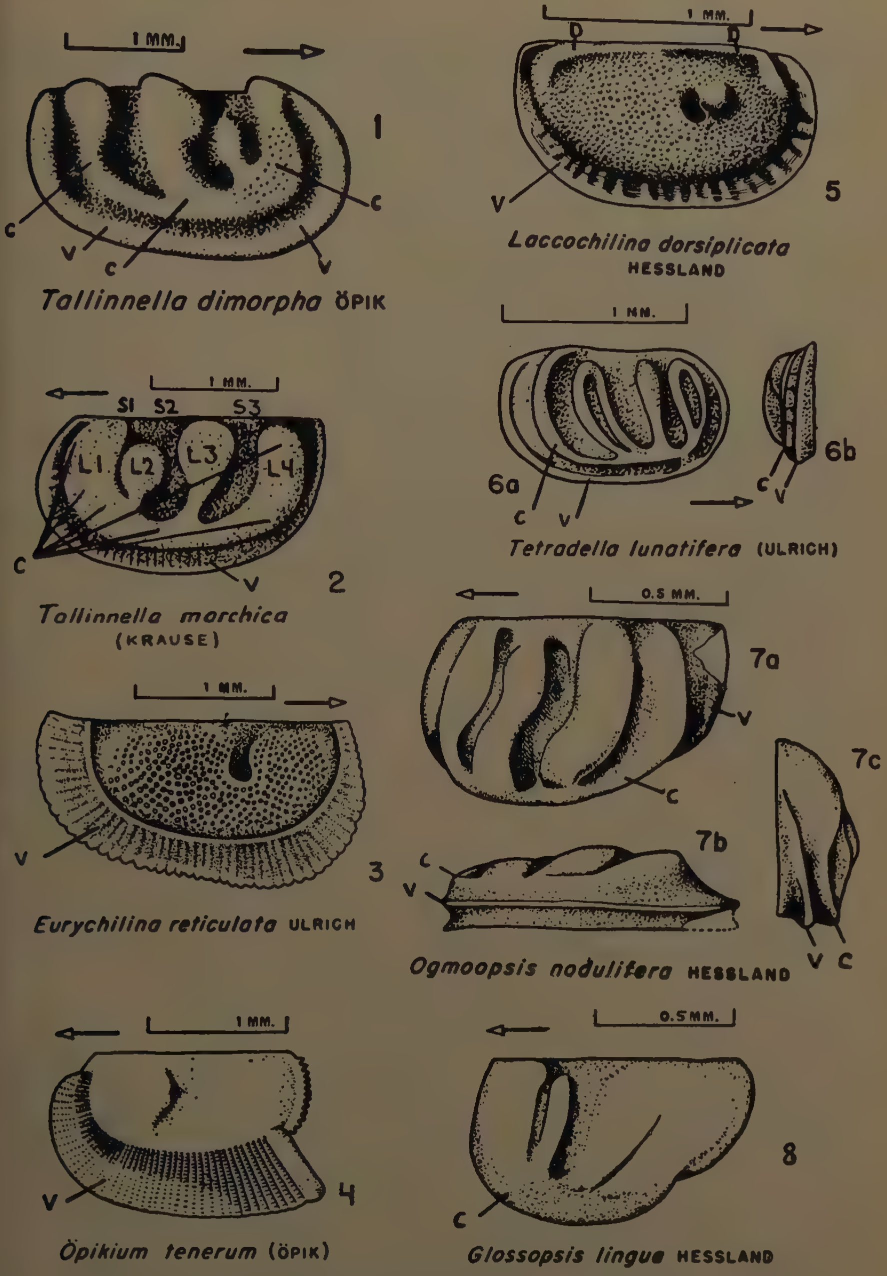

1 MM.
1
C
C
V
C
V
Tallinnella dimorpha ÖPIK
1 MM.
D
D
5
V
Laccochilina dorsiplicata HESSLAND
1 MM.
S1 S2 S3
L1 L2 L3 L4
C
V
2
Tallinnella marchica (KRAUSE)
1 MM.
6a
6b
C
V
C
V
Tetradella lunatifera (ULRICH)
1 MM.
V
3
Eurychilina reticulata ULRICH
0.5 MM.
7a
V
C
7c
7b
C
V
Ogmoopsis nodulifera HESSLAND
V C
1 MM.
4
V
Öpikium tenerum (ÖPIK)
0.5 MM.
8
C
Glossopsis lingua HESSLAND

Fig. 2. Examples of velate structures (V), carinal structures (C), and dorsal ridge (D). (The figures, not the symbols, are reproduced from KESLING, 1951b).

Special terms are such as anterior lobe, median sulcus, velate frill, etc. The terminology here follows that of KESLING (1951b) except for the addition of the terms lobate area and extralobate area, and the definition of carina. The *lobate area* (HESSLAND, 1949: sulcate area) comprises the lobes and the intervening sulci. The *extralobate area* (introduced by HESSLAND, 1949) denotes the rest of the valve between the lobate area and the free border. KESLING (1951b, p. 118) defines *carina* as "A frill-like or ridgelike structure dorsal and parallel to the velate structure. A frill or velate ridge must also be present to have a structure designated as a carina". The writer strongly disagrees with this last statement. Velate and carinal structures are not homologous (cf. HESSLAND, 1949, p. 130), and a carinal structure can be distinguished even if no velate structure is developed (text fig. 2; *2*). The *velate structure* may be developed as a velate frill, false border, row of spines, or a combination of these, and probably also as a velate bend. If the velate structure runs from the anterior to the posterior cardinal angle (or almost so) it may be called *entire* (text figs. 2; *1*, *2*, *3*, *5*, *6*). If it is restricted to the anterior and ventral border areas, and is not developed in the posterior border area, it may be called *restricted* (text fig. 2; *4*). The velate structure may be dimorphic.

Carinal structures. L1, L4 and the connecting ridge between these may be called a carinal ridge (text figs. 2; *1*, *2*). In tetralobate species the ventral ends of L2 and L3 may be united with this ridge (e.g. *Tallinnella*) or not (e.g. *Zygobolba*). Sometimes, at least a part of the carinal structure may form a protruding flange (HESSLAND, 1949, p. 130: ventral carina), as in *Glossopsis* (text fig. 2; *8*). The carinal structure may also be developed as a carinal crest, carinal bend (Umbiegungskante), etc. It may be dimorphic.

HESSLAND (1949, p. 129) introduced the symbols L1, L2, L3, L4 for the lobes (and C1, C2, C3, C4 for the corresponding crests), and S1, S2, S3 for the sulci. L1 denotes the anterior lobe and S1 the anterior sulcus, etc. (text fig. 2; *2*). These symbols were accepted by KESLING (1951b) and are also used here.

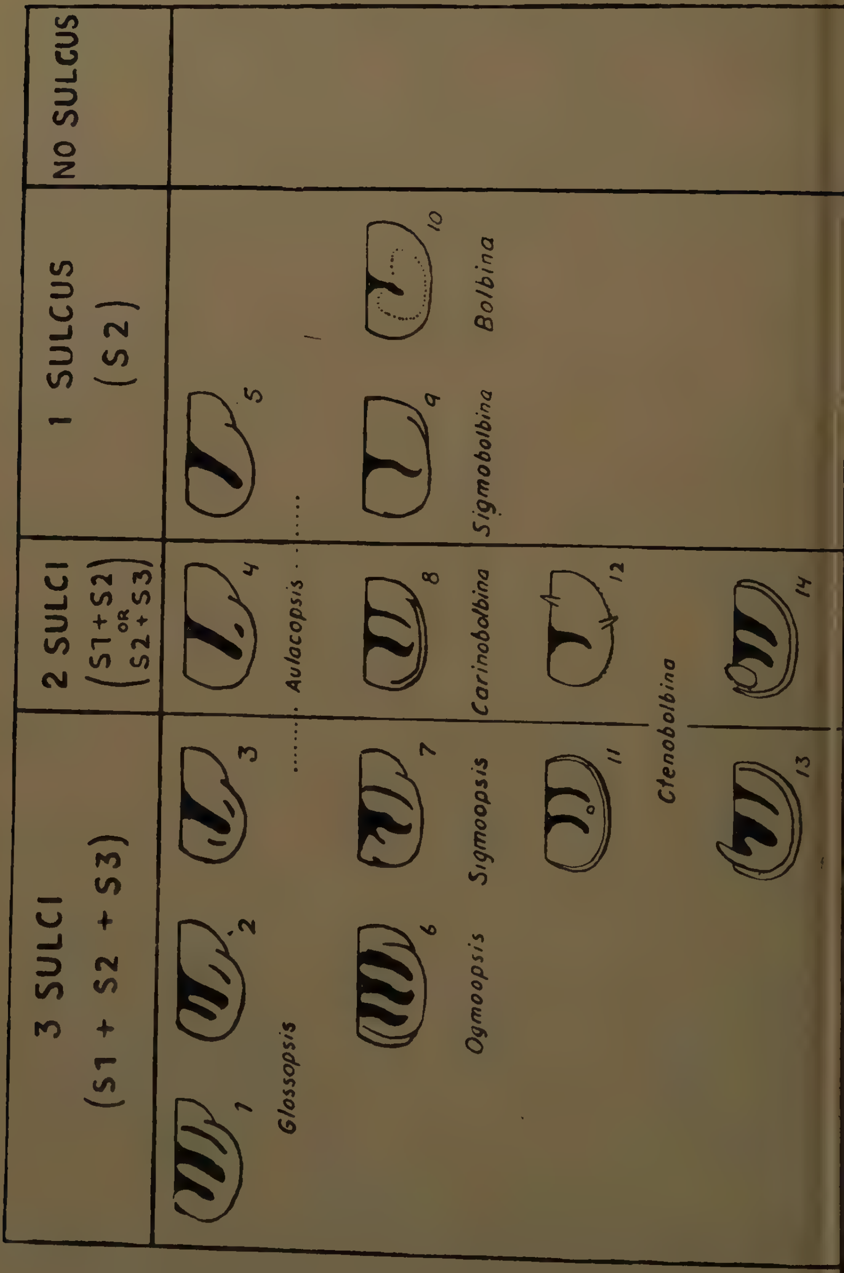
Degree of sulcation.

(Text figure 3).

The features mentioned above are liable to vary even in closely related species and need not be of greater taxonomic importance.

This does not exclude, however, that one or another feature (f. inst. development of certain crests or wide velate frills) may become fixed for a smaller or larger group. This appears to be generally accepted, but in the discussion of affinity too much stress seems to have been laid on as to whether the forms were non-, uni-, di-, or trisulcate. The writer quite agrees with SWARTZ (1936, p. 544) who points out that the degree of sulcation and lobation is of questionable genetic significance, and must be used cautiously. No doubt a unisulcate form may be closer to a trisulcate form than to other unisulcate forms, and vice versa. Compare (text fig. 3) f. inst. such pairs as *Glossopsis* — *Aulacopsis*, *Dizygopleura* — *Eukloedenella*, etc. The variation of the number of sulci is only an example of the common alternation between "smooth" forms (with "effaced relief") and forms with more or less well developed relief, also well-known in many other groups of shell-bearing animals. The pronounciation or obliteration of the sulci may be directly compared with that of the glabellar furrows in trilobites (cf. HENNINGSMOEN, 1951, p. 176). The sulci, at least S1 and S2 (cf. TRIEBEL, 1941, p. 310) may be assumed to represent points of muscle attachment. The same muscles may be assumed to be present also when no sulci are developed. The absence of sulci, or the presence of 1—3 sulci does not therefore indicate any important differences in the animal itself, but only modifications of the valve, which may be due to f. inst. mode of habitat. The smoothness of the valves is, to some degree, related to the convexity of the valves, length of the hinge, etc.; strongly convex forms with short hinge line are usually smooth (cf. TRIEBEL, 1941, p. 301).

In the discussion of the affinity of beyrichiacean ostracods, the forms with two or three sulci have generally been regarded as being more advanced than forms with no or one sulcus. From the above, it appears probable that forms with more sulci may have developed from forms with no or one sulcus. In fact, phylogenetic lines from tri- or disulcate forms to uni- and nonsulcate forms seem to have been established, whereas the opposite is not known with certainty. Phylogenetic lines of this type may, however, be expected to be found. As examples of the former type (reduction of the number of sulci) may be cited the probable development of *Steusloffia* (1 sulcus) from *Tallinnella* (3 sulci) via *Rigidella* (2 sulci and a semisulcus). The unisulcate *Plethobolbina* appears to have developed from earlier zygobolbids, which are di- or trisulcate (cf. range chart, p. 237). Furthermore the uni- to nonsulcate *Eukloedenella* seems to appear


NO SULCUS
1 SULCUS (S2)
2 SULCI (S1+S2 OR S2+S3)
3 SULCI (S1 + S2 + S3)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Glossopsis
Aulacopsis
Ogmoopsis
Sigmoopsis
Carinobolbina
Sigmobolbina
Bolbina
Ctenobolbina

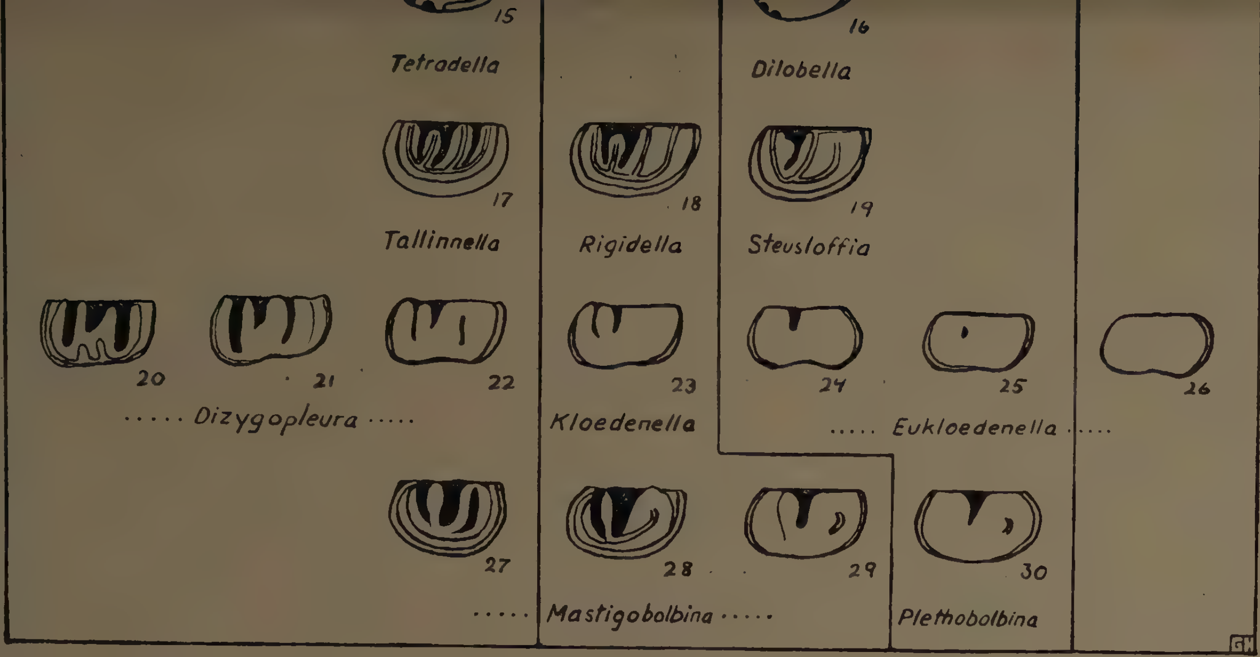


Fig. 3. Variation of sulcation in closely related forms. *1—5* Glossopsiinae (*1 Glossopsis acuta, 2 G. lingua, 3 Aulacopsis bifissurata, 4 A. monofissurata, 5 A. plana*), *6—12* Sigmoopsiinae (*6 Ogmoopsis nodulifera, 7 Sigmoopsis platyceras, 8 Carinobolbina estona, 9 Sigmobolbina kuckersiana, 10 Bolbina ornata, 11 Ctenobolbina ciliata, 12 C. bispinosa*), *13—17* Tetradellinae (*13 Ceratopsis chambersi, 14 C. quadrifida, 15 Tetradella quadrilirata, 16 Dilobella fulcrata, 17 Tallinnella grewingki*), *18—19* Bassleratiinae (*18 Rigidella* cf. *mitis, 19 Steusloffia polynodulifera*), *20—26* Kloedenellinae (*20 Dizygopleura costata, 21 D. stosei, 22 D. affinis, 23 Kloedenella rectangularis, 24 Eukloedenella sinuata, 25 E. umbilicata, 26 E. indivisa*), *27—30* Zygobolbinae (*27 Mastigobolbina bifida, 28 M. arguta, 29 M. punctata, 30 Plethobolbina typicalis*). (The sketches have been drawn after illustrations given by various authors.)

slightly later than the trisulcate *Dizygopleura*. It is possible that some of these uni- and nonsulcate genera are not strictly monophyletic, but include species which have developed from the allied tri- or disulcate forms at different times. When studying a form series from a trisulcate to uni- and nonsulcate forms, it is seen that a sulcus may become obliterated in two ways. In the one case the sulcus becomes shorter, to be replaced by a sulcal pit before it vanishes (text figs. 3; *20—26*), or a sulcus may be substituted by a semisulcus and then disappear, as seems to be the case in the phylogenetic line *Tallinnella* — *Rigidella* — *Steusloffia*. The width of the sulci (and the lobes) also appears to vary rather much even in closely related forms. It is of interest to note that one of the very earliest beyrichiacean forms is the tetralobate *Tallinnella primaria* ÖPIK, 1935 or a closely related form (cf. p. 213).

Persistent features.

It is always S2 which is developed in unisulcate forms. S2 may be said to be more persistent than S1 and S3 (for this reason S1 and S3 have been called secondary sulci by SWARTZ, 1936, p. 551). In forms with two sulci, the second sulcus may be either S1 or S3; in some groups it appears that S1 is more persistent than S3, whereas the opposite is the case in other groups. Regarding a form series from sulcate to nonsulcate forms (text figs. 3; *20—26*), it is seen that the sulcus diminishes and becomes a pit, corresponding in position to the middle and deepest part of the fully developed sulcus. This is the most resistent part of the sulcus. In the Glossopsiinae (text figs. 3; *1—5*) the ventral end of the sulcus (at least in S1 and S3) is the most persistent part of the sulcus. The most persistent lobe is usually L2. The velate structure is very persistent in the beyrichiacean ostracods, but may be lacking, as in some Glossopsiinae. In more or less smooth ostracods, features which are well developed in closely related, more ornamented forms appear "effaced" or may be completely lacking. The persistent features may be both "effaceresistent" and persistent in phylogenetic lines.

Criteria of affinity in beyrichiacean ostracods.

The degree of sulcation, width and height of lobes, width and depth of sulci, width of velate structure, etc. may vary in closely related forms. Nevertheless, some of these characters may become more or less fixed, and may then serve as criteria of affinity in some groups. The importance of such characters appears, however, to have often been overestimated.

The overestimation of the importance of the number of sulci is, to some degree, responsible for the inclusion in *Primitia* of a great number of unisulcate species with short sulcus, whereas those with a long sulcus have often been classed as unisulcate *Ctenobolbina* or *Ctenentoma* species. Similarly, disulcate forms with S2 and S3 are often assigned to *Ctenobolbina*, whereas forms with S1 and S2 have been placed in *Beyrichia*. Ordovician trisulcate species are usually included in *Tetradella*. In the writer's opinion this classification is too ''mathematical'' and does not pay proper attention to the affinity of the forms.

As in other groups of animals it is best to combine as many features as possible in tracing affinity. This does not exclude that a single, rare feature may be often very useful in establishing relationships.

The type of median sulcus (S2) (i.e. its shape, not its width or depth) has been found useful in some cases; also the types of lobes. Furthermore, the type of velate and carinal structures may be used as criteria of affinity, especially when they show dimorphism. When present, dimorphism may be of great help, as there are many different types of dimorphism, and these appear to be of supra-generic importance.

More or less smooth ostracods have caused much trouble in the taxonomy. It is often a good idea to compare these with contemporaneous ornamented forms and see if there is a form series from the one type to the other. The persistent features are often useful in tracing the affinity of smooth forms.

Dimorphism.

Several types of dimorphism have been described in the Beyrichiacea. Usually the one dimorph develops an extra swelling of the valve wall, or a more or less closed extraneous chamber or shelter. This dimorph is usually called the female. In *Beyrichia* the swelling (pouch) of the valve wall has been shown to be a brood pouch (HESSLAND, 1949, p. 124; SPJELDNÆS, 1951, p. 748), which supports the view that the pouch-bearing dimorph is the female.

It is possible that these forms are only fertilized females. Furthermore larval carapaces more or less agree with the so-called males. It may therefore be better to refer to these dimorphs as "female type" and "male type", the latter also probably including larval instars and possibly unfertilized females.

HESSLAND (1949, pp. 123—128) stresses the important difference between pouches formed by the carapace wall and the false pouches formed as extraneous chambers.

Orientation.

The Beyrichiacea are so oriented that the median sulcus (S2) generally is situated slightly in front of the middle in adult individuals. Non-sulcate beyrichiaceans are oriented in agreement with the nearest related sulcate forms. The orientation of Beyrichiacea has been thoroughly discussed by TRIEBEL (1941). Criteria for determining the orientation have been summarized by LEVINSON (1950, p. 65), and KESLING (1951, p. 94). As discussed below (p. 251) moult retention furnishes further support for this orientation. This orientation has sometimes been questioned for the brood pouch of *Beyrichia* would then have an anteroventral position, which would be an unusual feature. There seems, however, to be little doubt now that the dimorphic swellings of the Beyrichiidae and Kloedenellidae are developed in opposite ends of the carapace. If the orientation of the Beyrichiidae were reversed, this would imply that the orientation of the Kloedenellidae should also be reversed thus bringing *their* dimorphic swelling at the anterior end. The above-mentioned argument against the present orientation is thus considerably weakened.

Reversal of the valves.

COOPER (1941, p. 56) states that "The large number of reversed forms of *Sansabella* which have been discovered in the Chester series has shown the fallacy of trying to determine generic classification by overlap alone". And further (l.c., p. 59) "All other features being equal, the reversal of valves is not considered to be a generic or even specific character of the Kloedenellidae".

According to SOHN (1950, p. 35) *Aurikirkbya wordensis* (HAMILTON, 1942) has been proved to contain individuals that have a reversal of overlap and hingement. Similarly KELLETT (1936, p. 770) believes, as suggested by JOHNSON (1936, p. 7), that *Paraparchites oviformis* CORYELL & ROGATZ, 1932 and *Antiparaparchites reversus* CORYELL & ROGATZ, 1932 are not only congeneric, but also conspecific.

It appears thus questionable to recognize genera or species which differ from others in the reversal of valves only.

Remarks on the classification of Beyrichiacea.

The classification of the Beyrichiacea has often been revised. Good progress was made by SWARTZ (1936) who stresses that the degree of sulcation and lobation is of questionable genetic significance. In addition to the families recognized by BASSLER & KELLET (1934) in the "Index" (Primitiidae, Beyrichiidae, Zygobolbidae, Kloedenellidae, Kirkbyidae, Glyptopleuridae, and Youngiellidae), SWARTZ erected the families Hollinidae, Tetradellidae, Drepanellidae, Aechminidae, Acronotellidae, and Primitiopsiidae. These families were split off from the families Primitiidae and Beyrichiidae, which had become too heterogeneous. SWARTZ removed the Eurychilininae from the Primitiidae to the Beyrichiidae, comparing the false pouch of the Eurychilininae with the pouch of the Beyrichiidae.

BOUČEK in a paper appearing slightly earlier (July 1936) than that of SWARTZ (October 1936) divides the Primitiidae into four subfamilies; besides Primitiinae and Eurychilininae the new subfamilies Bolliinae and Aechmininae.

ÖPIK (1937) adds the family Piretellidae.

KAY (1940) follows BOUČEK regarding the Primitiidae, but adds one more subfamily, the Dilobellinae. The Tetradellinae and Piretellinae are regarded as subfamilies of the Beyrichiidae. The writer agrees with SWARTZ (in SWARTZ & SWAIN, 1941, p. 416) that KAY's return to primary emphasis on the degree or strength of lobation is a backward step and leads to unnatural assemblages.

SCHMIDT (1941) follows SWARTZ to a certain extent, but seems to lay too much stress on the number of sulci. SCHMIDT includes the Tetradellinae as a subfamily of the Hollinidae, together with the two new subfamilies Ctenentominae and Ctenonotellinae. Furthermore the Aechmininae and the new subfamilies Ulrichiinae and Bassleratiinae are included in the Drepanellidae. The Primitiopsiinae are included in the Primitiinae, together with the Primittiinae and Eurychilininae.

HESSLAND (1949) agrees with SCHMIDT, except for the transference of the Eurychilininae from the Primitiidae to the Hollinidae, and also in including in this family the new subfamily Euprimitiinae. HESSLAND points out the important difference between the false pouch of f.inst. the Eurychilininae and the pouch of the Beyrichiidae.

The classification proposed here agrees best with that of SWARTZ (1936). When the present writer deviates from his classification in several points, this is mainly due to:

1) SWARTZ recognized *Primitia mundula* as type species of *Primitia*, as had become the custom. The recognition of *P. strangulata* as the type species (cf. p. 225) influences the classification considerably.

2) SWARTZ did not distinguish between the extraneous false pouch of the Eurychilinidae and the pouch of the Beyrichiidae, the latter pouch opening into the main cavity of the carapace. SWARTZ thus included the eurychilinids in the Beyrichiidae.

3) New material, especially of important early forms has been described since the appearance of his paper.

4) The writer has continued the "splitting up" of groups including forms with the same degree of sulcation and lobation, but probably not closely related.

Notes on affinities and trends of beyrichiacean families.

Some of the earliest known beyrichiacean ostracod faunas are those described by HESSLAND (1949) from the Lower Ordovician of the Siljan District in Sweden. They are also the largest early faunas described, and are of considerable interest in studying the affinities of beyrichiacean ostracod families.

A group of species with well defined velate or carinal structure was assigned to the genera *Euprimitia* (possibly not congeneric with the type species), *Euprimites*, *Eurychilina* (may be transferred to *Laccochilina*, cf. p. 228), *Laccochilina*, *Ctenentoma* (here transferred to *Aulacopsis* and *Hesslandella* gen. n.), *Aulacopsis*, *Glossopsis*, *Ogmoopsis*, *Ceratopsis* (Glossopsiinae, probably species of *Glossopsis*), *Tetradella* (here *Tallinnella*), and *Steusloffia*. In *Aulacopsis*, *Glossopsis*, and *Ogmoopsis* the carinal structure is the dominating submarginal structure, in the others it is the velate structure. When present, the velate structure is entire, and in the form of a wide frill, a narrow frill, or a ridge. The velate frill may show dimorphism, but of a simple type, in being convex in some individuals. In the writer's opinion all these species are rather closely related, and could have been grouped in one family. As discussed above (p. 193), the degree of lobation is perhaps of no great importance. When the above genera are here assigned to different subfamilies and families, this is because these groups are clearly differentiated in later faunas. It is always difficult to know how far back such groups should be separated. These early faunas are probably near the bursting point of several groups.

Tallinnella, *Hesslandella* gen. n. and probably *Euprimites* may be assigned to the Tetradellinae (cf. p. 214). It is interesting to note that *Tallinnella* includes species with velate rim (as in *Hesslandella* gen. n. and *Euprimites*), forms with wide frill (as in *Laccochilina*), and forms with narrower frill (crest) and crests along the lobes (as in *Steusloffia*). *Steusloffia* is here assigned to the Bassleratiinae, although it is hardly to be doubted that the early *Steusloffia* and *Tallinnella* are very closely related. As discussed below (p. 223) it appears most reasonable to assume that *Steusloffia* developed from *Tallinnella*. *Laccochilina* shows the same type of frill as f.inst. *Tallinnella grewingki*, and might just as well have been included in the Tetradellinae as in the Eurychilininae.

Aulacopsis, *Glossopsis*, and *Ogmoopsis* are here included in the family Sigmoopsiidae nov., characterized i.a. by the well developed carinal structure. There is, however, hardly any doubt that this group is closely related to early Tetradellinae, and that they had common origin, probably not far back in time.

It would, of course, be of interest to study still older faunas. The only likely older fauna related to those discussed above, is that of the Megalaspis Limestone described by ÖPIK (1935). It comprises i.a. *Ogmoopsis bocki*, *Tallinnella primaria*, *Rigidella mitis*, and *Laccochilina estonula*, all erected by ÖPIK, 1935. This fauna is probably slightly older than the one in the lower part of the succession described by HESSLAND.

Tallinnella primaria (or a very closely related form) has been observed by the writer in still older beds (Lower Didymograptus Shale) in Norway, and is probably the earliest known beyrichiacean species with velate structure.

One may possibly regard the Tetradellinae as a main stock. The Sigmoopsiidae (Sigmoopsiinae and Glossopsiinae) may have branched off from this, or at least had a common origin. *Steusloffia* (and thus probably the whole subfamily Bassleratiinae) has most probably developed from the Tetradellinae, and this may be true of the Eurychilininae, too.

Proceeding now to later Ordovician beyrichiacean faunas, new groups appear, and the whole picture is more varied. The subfamily Sigmoopsiinae develops a number of new forms (*Sigmoopsis*, *Sigmobolbina*, etc.), and likewise the Tetradellinae. The velate structures and velate dimorphism become more differentiated, producing forms like *Tallinnella dimorpha*. In this species the dimorphic part of the frill is restricted to its anterior part; the frill, however, is still entire. The Piretellinae (including forms like *Piretella* and *Rakverella*) includes forms with restricted frill (not seen in early Ordovician genera). They have most probably developed from the Tetradellinae, where forms like *Tallinnella dimorpha* and *Tallinnella superciliata* point towards the Piretellinae regarding the structure of the frill and its dimorphism. The Primitiidae have appeared. They may have developed from the Tetradellinae such as (or *via*) forms like *Piretella*, or, possibly from the Eurychilinidae, still represented here. *Steusloffia* is still present, as well as a number of other Bassleratiinae.

A difference between the early and later Ordovician faunas is that the velate and carinal structures are more varied in the later faunas, and there are more types of dimorphism.

The relationships of the Acronotellidae, Primitiopsiidae, and Aparchitidae to the above-mentioned families are still uncertain. The Aparchitidae comprises smooth forms which may have developed from one (or more) of these families.

The relationships of later families (appearing in Silurian and later systems) to the Ordovician families are still rather obscure. Such relationships can quite probably be traced when more forms have been studied, especially from near the Ordo-Silurian boundary.

It still seems uncertain whether the Beyrichiidae developed from the Eurychilinidae (as is often suggested) or some other Ordovician family. It is also not quite certain that the Kirkbyidae developed from the Bassleratiinae *via Strepula*, which has sometimes been included in the Kirkbyidae. As discussed below (p. 239) the Hollinidae may not be closely related to *Ctenobolbina* as is generally believed. The relationships of the Kloedenellidae to the Ordovician or later families are also uncertain. As discussed below (p. 245) the glyptopleurids are, however, closely related to the kloedenellids, and have for this reason been included in the Kloedenellidae. The position of the very little known families Youngiellidae and Miltonellidae is quite uncertain.

The Silurian beyrichiid faunas are especially characterized by the dimorphic swellings of the Beyrichiidae and Kloedenellidae. Furthermore wide velate frills are not so common as in Ordovician faunas.

Very few post-Silurian beyrichiaceans develop a well-marked dimorphic swelling. Instead overlap features become more prominent.

Early families.

These are the families which entirely or partly consist of Ordovician genera.

Family Sigmoopsiidae nov.

Diagnosis: — See p. 262. *Included genera:* — See list p. 266.

Remarks: — Characteristic for this family is especially the carinal structure which is often well developed, and often shows dimorphism, whereas a velate dimorphism is usual in other early families.

The family includes the two new subfamilies Sigmoopsiinae and Glossopsiinae. It appears probable that these two groups had common ancestors, which may have developed from early forms of *Tallinnella,* or at least from the same stock as *Tallinnella.* It is, however, also possible that the Sigmoopsiinae and Glossopsiinae represent two different off-shoots from the Tetradellinae. If so, they may be assumed to be rather "closely set" off-shoots, which may justify their grouping together.

Subfamily Glossopsiinae nov.

(Text fig. 3, *1—5*).

Diagnosis: — See p. 262. *Included genera:* — See list p. 266.

Remarks: — This is a well defined subfamily, showing several unusual features. There are no or very faint velate structures. Instead the carinal structure is well developed as a flange (carina). The sulci are rather long; S3 is more persistent than S1. It is remarkable that the ventral part of S1 and S3 is the most persistent part of these sulci. *Ctenentoma plana* HESSLAND, 1949 should be removed from *Ctenentoma* (cf. p. 224). HESSLAND (1949, p. 268) states that it will probably be referred to a new genus or subgenus, and that this species may be closely related to *Aulacopsis*. The difference between *C. plana* and *Aulacopsis monofissurata* HESSLAND, 1949 is very small; the latter differing in having a very faint impression corresponding to the ventral part of S3. In the writer's opinion *C. plana* should be transferred to *Aulacopsis*, which would then also include unisculate species. It appears unnecessary to erect a new genus for *Aulacopsis plana* alone. *Aulacopsis nodosa* HESSLAND, 1949 should on the other hand be removed from this genus. It does not have a carinal structure, but instead a well defined velate structure. As stated by HESSLAND (1949, p. 281) it is closest reminiscent of *Ctenentoma macroreticulata*, which is designated the type species of a new genus, *Hesslandella* (cf. p. 215). *Aulacopsis nodosa* should be included in this genus.

As demonstrated by HESSLAND, *Aulacopsis plana* shows a dimorphism in the carinal structure; the carina being better defined in some individuals (type *a*) than in others (type *b*). In the writer's opinion the same applies to *Glossopsis*, but its two types have been described as different species. *G. lingua* appears to be type *a* and *G. clavata* type *b* of the same species, which should then be called *G. lingua*. Similarly *G. acuta* may probably be type *a* and *G. tenuilimbata* type *b* of one species, which should be called *G. acuta*. The following comparison is rather interesting (based on data from HESSLAND, 1949):

Aulacopsis plana	type *a*	17	valves measured,	"mean size"	1.20	mm
—»—	type *b*	22	—»—	—»—	0.85	»
Glossopsis acuta	(type *a*)	369	—»—	—»—	0.97	»
(*G. tenuilimbata*)	(type *b*)	537	—»—	—»—	0.78	»
Glossopsis lingua	(type *a*)	131	—»—	—»—	1,04	»
(*G. clavata*)	(type *b*)	238	—»—	—»—	0.73	»

The table shows that type *b* of *Aulacopsis plana* is the more common one, but having the smaller "mean size" in the collected material. It is interesting to note that *G. clavata* which morphologically may represent type *b* of G. *lingua* is more common, and has a smaller "mean size" in the collected material than *G. clavata*. The same is the case with *G. tenuilimbata* vis-a-vis *G. lingua*. In *A. plana* the smallest carapace of type *a* which was measured, is slightly longer than the largest carapace measured of type *b*. In *G. lingua* the smallest carapace measured has practically the same length as the largest carapace of *G. clavata*. This may favour the view held by HESSLAND (1949) that the types *a* and *b* represent adult and larval instars, respectively. Regarding *G. lingua* and *G. tenuilimbata* there is a certain overlap with regards to size, and it is possible that type *a* represents mature females, whereas type *b* represents mature males and larval instars.

HESSLAND (1949, p. 296) distinguishes between a *G. lingua* and a *G. tenuilimbata* group, assigning to the former *G. lingua* and *G. acuta*. As *G. tenuilimbata* may be a synonym of *G. acuta*, these groups may be united. The third group recognized by HESSLAND, the *G. perpunctata* group, is here assigned to the new genus *Sigmoopsis*.

Subfamily Sigmoopsiinae nov.

(Text fig. 3; *6—12*).

Diagnosis: — See p. 262. *Included genera:* — See list p. 266.

Remarks: — Rather characteristic of this subfamily is the sigmoidal median sulcus (S2) and the corresponding shape of L3, which often appears slightly constricted ventrally. Furthermore these genera both have a velate and a carinal structure, the latter showing dimorphism (or may be missing in the one dimorph). This was already observed by BONNEMA (1909) in the species *Ctenobolbina carinata* KRAUSE sp. (here: *Carinobolbina estona* (ÖPIK, 1937)) and *Ctenobolbina Kuckersiana* BONNEMA, 1909 (= *Carinobolbina kuckersiana*). As pointed out by ÖPIK (1937, p. 26) and KESLING (1951, p. 108) *"Ceratopsis" obliquejugata* and allied (here assigned to *Sigmoopsis* gen. n.) show dimorphism in the carinal structure (referred to by these authors as "false border" and "velate structure" respectively).

Notes on the genera: —

Ogmoopsis HESSLAND, 1949.

(Text fig. 3; *6*).

Ogmoopsis (type species *O. nodulifera* HESSLAND, 1949) is the earliest known genus of the Sigmoopsiinae. It is a typical member with sigmoidal median sulcus (S2), L3 somewhat restricted ventrally, and with a velate ridge as well as a carinal flange (carina). *O. paene-*

quisulcata HESSLAND, 1949 does not have the typical S2 and L3, and should probably rather be included in the Glossopsiinae (*Glossopsis*).

Sigmoopsis gen. n.

(Text fig. 4).

Derivation of name: — From "sigma" and "opsis" (appearance), alluding to the sigmoidal median sulcus.

Type species: — *Ceratopsis platyceras* ÖPIK, 1937. This species is chosen as type species as it is well described and illustrated by ÖPIK (1937, p. 26; pl. II, figs. 6—7; pl. X, figs. 12—14; pl. XIV, fig. 5) (Also refigured by KESLING, 1951, pl. VI, figs. 2—3). It is possible that *S. platyceras* may be shown later to be a synonym for one of the German drift boulder species, but the writer prefers not to select any of these as type species, as they are not very well known, and their stratigraphic horizon somewhat uncertain.

Diagnosis: — Carapace usually elongated, with forward swing. 2—3 sulci. S2 sigmoidal, with geniculum and backward curve of ventral end. S3 of about same length as S2, S1 much shorter or missing. L1 sometimes extended into a spine-like process dorsally. L2 short, not inclined to be bulbous. L3 bluntly constricted at its ventral end. Lobate area well separated from the extra-lobate area by the carinal structure, except postero-dorsally, where the dorsal half of L4 may be confluent with the extralobate area. The carinal structure usually shows dimorphism, being developed as a ridge or a protruding flange (carina). An entire crest-like velate structure is present.

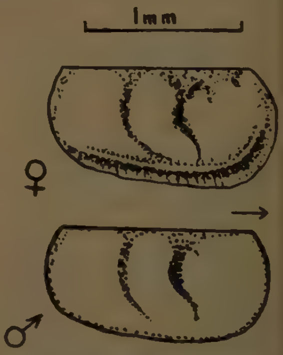


Fig. 4. *Sigmoopsis platycera* (ÖPIK, 1937). Reproduced from the drawings given by KESLING (1951, pl. VI, figs. 2—3) after photographs given by ÖPIK (1937,pl.II,figs.6-7).

Remarks: — This is a very characteristic genus. Its species have earlier been assigned to *Beyrichia*, *Ctenobolbina*, and *Ceratopsis*. *Sigmoopsis* gen. n. is clearly different from *Beyrichia*, and differs from this genus and *Ceratopsis* in the sigmoidal S2, sausage-like L3, and the carinal structure (showing dimorphism). It may, however, be related to *Ctenobolbina* (cf. p. 211) which has no carinal flange. The "*Glossopsis perpuncta* group" of HESSLAND (1949, p. 297) consists of typical *Sigmoopsis* species. *Sigmoopsis* differs from *Glossopsis* in the shape of the lobes and sulci, and in having a distinct velate ridge. It may be recalled that KESLING (1951, p. 108) states that *Ceratopsis* has some dimorphic species, and mentions *C. platyceras* and *C. obliquejugata*, both of which are here included in *Sigmoopsis*. The following forms may be assigned to *Sigmoopsis* gen. n.:

Sigmoopsis obliquejugata (SCHMIDT, 1858)
» *perpuncta* (ÖPIK, 1937)
» *perpuncta prominens* (ÖPIK, 1937)
» *platyceras* (ÖPIK, 1937)
» *rostrata* (KRAUSE, 1892)
» *rostrata cornuta* (KRAUSE, 1896)
» *schmidti* (BONNEMA, 1909)

A closer study of these forms may show that some are synonyms. ÖPIK (1937, p. 25) claims that *S. schmidti* appears to be identical with *S. obliquejugata*. If so it is quite probable that *S. platyceras* is also a synonym of *S. obliquejugata*. Furthermore some of the N. German drift boulder species may turn out to be conspecific with Baltic forms.

Carinobolbina gen. n.

(Text fig. 5).

Type species: — *Ctenobolbina estona* ÖPIK, 1937 (= *Ctenobolbina carinata* KRAUSE in BONNEMA, 1909).

Remarks: — This genus is rather close to *Sigmoopsis* but differs in that the carinal structure is shorter, mainly being confined to the anteroventral and ventral areas. *Carinobolbina* is also probably close to *Ctenobolbina* but in the latter genus the carinal structure is still more reduced, forming a spine or alate extension only.

Species: — Besides *Ctenobolbina estona* ÖPIK, 1937, *Beyrichia* (*Tetradella*) *carinata* KRAUSE, 1892 and *Ctenobolbina kuckersiana* BONNEMA, 1909 are typical members. *Ctenobolbina aspera* ÖPIK, 1937 is not well enough known. If the submarginal crest seen in the specimen figured by ÖPIK (1937, pl. VIII, fig. 5) is a carinal structure, *C. aspera* is no doubt closely related to *C. kuckersiana* and should

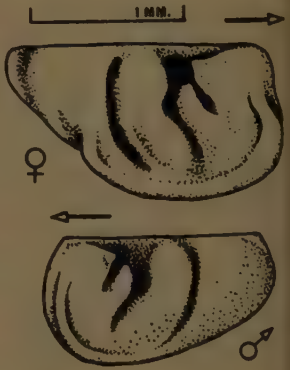


Fig. 5. *Carinobolbina estona* (Öpik, 1937). Female type after Öpik (1937, pl. VIII, fig. 8), male type after Bonnema (1909, pl. II, fig. 20).

be included in *Carinobolbina*. *Ctenobolbina polytropis* Öpik, 1937 and *Ctenobolbina ctenolopha* Öpik, 1937 have rather unusual types of carinal structures; parallel rows of pits with or without ridges between the rows. Apart from this, they agree very well with the Sigmoopsiinae, especially *Carinobolbina* and should probably be included in this genus. The following species are thus assigned to *Carinobolbina:*

Carinobolbina estona (Öpik, 1937)
» *carinata* (Krause, 1892)
» *kuckersiana* (Bonnema, 1909)
» ? *aspera* (Öpik, 1937)
» ? *polytropis* (Öpik, 1937)
» ? *ctenolopha* (Öpik, 1937)

Sigmobolbina gen. n.

(Text fig. 6).

Derivation of name: — The name alludes to the sigmoidal median sulcus, and the likeness to *Ctenobolbina*.

Type species: — *Entomis oblonga* Steusloff var. *Kuckersiana* Bonnema, 1909 = *Sigmobolbina kuckersiana* (Bonnema, 1909), from Middle Ordovician Kukruse Beds, Esthonia.

Diagnosis: — Carapace elongate, with anterior swing. Unisulcate, although one may sometimes see traces of S1 and S3. Median

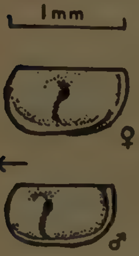


Fig. 6. *Sigmobolbina kuckersiana* (Bonnema, 1909). Female type after Bonnema (1909, pl. V, fig. 9), male type after Bonnema (1909, pl. V, fig. 6).

sulcus (S2) sigmoidal, as in *Sigmoopsis* gen. n. Velate ridge narrow but distinct. Carinal structure shows dimorphism; may be developed as a flange (female type) or as a ridge (male type), often ending in a spur posteriorly.

Remarks: — Species here assigned to *Sigmobolbina* gen. n. were stated by Kay (1940, p. 254) to seem congeneric with *Winchellatia*. This is possible, but *Winchellatia*, as described by Kay, appears to differ in having a velate dimorphism (not carinal), and furthermore its sulcus is not distinctly sigmoidal. It is, however, quite possible that the spine of *Winchellatia* corresponds to the spur of *Sigmobolbina*. There is no doubt that *Sigmobolbina* is closely related to *Sigmoopsis*, and may regarded as the unisulcate equivalent of this. For this reason *Sigmobolbina* may be regarded as a subgenus of *Sigmoopsis*.

The different forms assigned to *Sigmobolbina* vary especially in the development of the carinal structure. In some species it is rather flange-like (at least in the one dimorph), and posteriorly it may fade away or be extended into a spur. In some forms (cf. *S. obliqua* in Thorslund, 1940) the area between this spur and the sulcus tends to be swollen, forming a kind of a ventral lobe.

Besides the type species, *Entomis variolaris* Bonnema, 1909 and *Entomis obliqua kuckersiana* Bonnema, 1909 belong no doubt to *Sigmobolbina*. *Entomis oblonga* Steusloff, 1894 may belong here, f the specimens described under this name by Krause (1896, p. 935) eally are conspecific. These specimens should undoubtedly be ssigned to *Sigmobolbina*. *Entomis obliqua* Krause, 1892 is also ongeneric; also the specimens described by Thorslund (1940, p.173). *Entomis sigma* Krause, 1889 probably belongs to *Sigmobolbina*, lthough probably not the variety later called var. *antiquata* by Krause (1891, p. 509). The latter form may be an *Öpikium* species. t is also uncertain whether *Entomis sigma ornata* Krause, 1891 elongs here. *Ctenobolbina mammilata* Thorslund, 1940 may belong ere. Only one specimen is known, and it is therefore not ascertained f it is dimorphic and thus which type of dimorphism it displays. *Vinchellatia gunnari* Thorslund, 1948 should probably be assigned o *Sigmobolbina*, although in that case probably only the one dimorph male type) has been described. *Ctenobolbina?* aff. *obliqua* Krause escribed by Öpik (1937) is undoubtedly either a *Sigmobolbina* or *Bolbina* species. The following species may thus be included in *igmobolbina* gen. n.:

Sigmobolbina kuckersiana (Bonnema, 1909)
» *obliqua* (Krause, 1892)
» *obliqua kuckersiana* (Bonnema, 1909)
» *oblonga* (Steusloff, 1894)
» *sigma* (Krause, 1889)
» *variolaris* (Bonnema, 1909)
» ? *gunnari* (Thorslund, 1948)
» ? *mammilata* (Thorslund, 1940)

It is possible that some of the above forms may later be shown to be synonyms. It may also be noted that *Sigmobolbina* (*oblonga*) *kuckersiana* and *Sigmobolbina obliqua kuckersiana* are homonyms, and cannot both be valid, whether they are considered subspecies or species. As a further study on these forms may prove that the one or the other may be a synonym for another species, none of them will be renamed here.

Bolbina gen. n.

(Text fig. 7).

Derivation of name: — The name indicates the likeness with *Sigmobolbina* and *Ctenobolbina*.

Type species: — *Bollia ornata* Krause, 1896, from Ordovician drift boulder in N. Germany.

Diagnosis: — Elongated, ends subequal, sometimes with faint forward swing. Sulcus (S2) of median length. L2 forms a swollen lobe, connected ventrally to a postero-ventral lobe. The latter may end in a spur-like conical process, and appears to be dimorphic. These lobes form a more or less U-shaped area, and may be more or less well distinguished from the surrounding area. Velate structure short and ridge-like, sometimes wide (dimorphism?). In the latter case the velate structure (frill) is widest postero-ventrally.

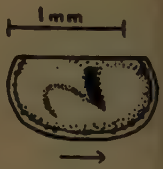


Fig. 7. *Bolbina ornata* (Krause, 1896). After Bonnema (1909, pl. IV, fig. 4).

Remarks: — *Bollia minor kuckersiana* BONNEMA, 1909, *B. minor robusta* BONNEMA, 1909, *B. ornata latimarginata* BONNEMA, 1909, and *B. ornata* KRAUSE, 1896 (as described and figured by BONNEMA, 1909) are no doubt congeneric. As suggested by BONNEMA (1909, p. 63) it is possible that *B. ornata latimarginata* (with wide velate frill) is only a dimorph of *B. ornata*. If this is so, this species appears to show dimorphism both in the carinal and velate structures. The postero-ventral lobe in *Bolbina* most probably corresponds to that sometimes seen in *Sigmobolbina* (especially in *S. obliqua*). It may therefore represent a carinal structure. It seems reasonable to assume that *Bolbina* has developed from *Sigmobolbina*. Because of the swollen U-shaped ridge, the sulcus in *Bolbina* is not as long as in *Sigmobolbina*, and cannot be sigmoidal. It agrees, however, very well with the corresponding part of the sulcus in *Sigmobolbina*. It is interesting to note that the velate structure, which has been developed as a velate ridge in earlier representatives of the Sigmoopsiinae (which may have developed from forms with wide frills), is again developed as a frill in *Bolbina ornata latimarginata*. Furthermore it is of interest to note that this frill is widest postero-ventrally, thus differing from the wide frills in other families.

Bollia minor ornata KRAUSE, 1896 is quite probably conspecific with the specimens assigned to this form by BONNEMA (1909). *Bollia minor* KRAUSE, 1892 and *Bollia major* KRAUSE, 1892 are no doubt congeneric, but the illustrations of these appear to be rather schematic. It is possible that some forms described by BONNEMA (1909) are conspecific. *Ctenobolbina? minor mitis* ÖPIK, 1937 appears to be congeneric. *Ctenobolbina* aff. *obliqua* KRAUSE described by ÖPIK (1937) is no doubt either a *Sigmobolbina* or *Bolbina* species. The following forms may thus be included in *Bolbina* gen. n.:

Bolbina major (KRAUSE, 1892)
» *minor* (KRAUSE, 1892)
» » *kuckersiana* (BONNEMA, 1909)
» » *robusta* (BONNEMA, 1909)
» » *mitis* (ÖPIK, 1937)
» *ornata* (KRAUSE, 1896)
» » *latimarginata* (BONNEMA, 1909)

Affinities: — Most of these forms have usually been assigned to *Bollia* JONES & HOLL. They are, however, probably not closely related to this genus, from which they differ i.a. in having a velate structure. The U-shaped area of *Bolbina* does not seem to be quite homologous with the U-shaped ridge of *Bollia*. *Bolbina* is, however, no doubt close to *Sigmobolbina* and *Sigmoopsis*, and is confidently included in the Sigmoopsiinae.

Kiesowia ULRICH & BASSLER, 1908.

Type species: — *Beyrichia dissecta* KRAUSE, 1892.

Diagnosis: — Carapace elongate, with more or less pronounced forward swing. The lobes are developed as one or more nodes. The carinal structure thus also consists of a row of nodes (or bluntly pointed spines). It is not known if the carinal structure is subject to dimorphism. The velate structure is developed as a row of small tubercles (spine bases ?). Median sulcus sigmoidal when well developed.

Remarks: — The type species was described from an Ordovician drift boulder in N. Germany. It is not very well known, only one drawing of it being given, and a none too detailed description. *K. pernodosa* and *K. margaritata*, both described by ÖPIK (1937), show so many features in common with *K. dissecta* that they may be regarded as congeneric and give us a more detailed picture of the genus. No doubt also *Beyrichia mammilosa* KRAUSE (1892) belongs here. The median sulcus (S2) of the Esthonian species is sigmoidal. *Beyrichia* ? sp. described by ÖPIK (1937) is also a *Kiesowia*. It is characteristic of *Kiesowia* that its lobes (and carinal structure) are split up into nodes. In this respect *Ctenobolbina* ? *octispina* ÖPIK, 1937 is rather similar. Here the carinal nodes are elongated into long and bluntly pointed spines. This species may perhaps belong to *Kiesowia*, in addition to the closely related *Entomis* (*Bursulella?*) *quadrispina* KRAUSE, 1892. *Beyrichia radians* KRAUSE, 1892, generally assigned to *Kiesowia*, has a wide frill, The following species may be included in *Kiesowia:*

Kiesowia dissecta (KRAUSE, 1892)
» *mammilosa* (KRAUSE, 1892)
» *margaritata* ÖPIK, 1937
» ?*octispina* (ÖPIK, 1937)
» *pernodosa* ÖPIK, 1937
» ?*quadrispina* (KRAUSE, 1892)
» *radians* (KRAUSE, 1892)

Affinities: — The general pattern of *Kiesowa*, well demonstrated in *K. margaritata* (Öpik, 1937, pl. XIV, figs. 7—8) reminds one of *Sigmoopsis*. The frill of *K. radians*, on the other hand, reminds one of the Tetradellinae, and *Kiesowia* is for the time being only tentatively included in the Sigmoopsiinae. *Kiesowia? octispina* appears to be a true sigmoopsiid.

Ctenobolbina Ulrich, 1890.

(Text fig. 3; *11—12*).

This genus has long been a typical "sack" genus, into which a number of disulcate forms of the morphological type S2—S3 have been placed, as well as a number of unisulcate forms which did not fit into *Primitia* or *Eurychilina*. Some of the latter have later been removed to *Ctenentoma* (cf. p. 224) and *Parabolbina* (cf. p. 239). *Ctenobina* is here restricted to the type species, *Ctenobolbina ciliata* (Emmons, 1855), and closely related forms.

Diagnosis: — Uni- to disulcate forms with entire velate structure, developed as a ridge or narrow frill. The sulci are long. Lobal area is continuous with the extralobal area. There are usually alate processes or a spur-like spine behind the ventral end of the median sulcus. Surface usually granulated.

Remarks: — As examples of this genus, besides the type species (*Ctenobolbina ciliata*), may be mentioned; *C. emaciata* Ulrich, 1890, *C. bispinosa*, and *C. alata* Ulrich, 1890. *C. jemtlandica* Thorslund (1940) may also belong here.

The alate processes may possibly represent rudiments of the carinal structure, and may be compared with the carinal spur of *Sigmobolbina* gen. n., possibly also with the spine of *Winchellatia*. According to Ulrich (1890, p. 110) the alate processes in *C. alata* "seem to be rather variable features, since in some examples, apparently in a good state of preservation, they are considerably smaller, and more spine-like than in those figured". It is thus possible that these features show dimorphism.

Affinities: — *Ctenobolbina* may be close to *Carinobolbina* gen. n., especially if the alate processes can be shown to be dimorphic. For this reason *Ctenobolbina* may belong to the Sigmoopsiinae. *Cteno-*

bolbina may probably not be closely related to the Hollinidae, as is generally accepted (cf. p. 239).

Winchellatia KAY, 1940.

Remarks: — The type species, *Winchellatia longispina* KAY, 1940, has a spur-like spine, rather like that of *Sigmobolbina* gen. n. If it corresponds to the carinal spur in *Sigmobolbina* gen. n. (which seems quite possible), the frill of *Winchellatia* is a velate structure. As this frill is stated to be dimorphic (Kay, 1940, p. 253), it is the velate structure which is dimorphic in *Winchellatia*, and not the carinal structure as in *Sigmobolbina* gen. n. In addition *Winchellatia* does not have such a well-defined sigmoidal median sulcus as *Sigmobolbina* gen. n. Further study may show if these genera are related. For the present *Winchellatia* is tentatively included in the Sigmoopsiinae.

Family Tetradellidae SWARTZ, 1936.

Diagnosis: — See p. 262. *Included genera:* — See list p. 266.

Remarks: — To the family Tetradellidae SWARTZ (1936, p. 551) originally attributed the following genera: *Tetradella*, *Dilobella*, *Ceratopsis*, *Kiesowia*, *Thomasatia*, *Bassleratia*, *Bellornatia*, and *Raymondatia*. The 4 last genera were transferred to the subfamily Bassleratiinae by SCHMIDT, 1941, who regarded the tetradellids as a subfamily of the Hollinidae. SCHMIDT included the following genera in the Tetradellinae: *Tetradella*, *Tallinnella*, *Ceratopsis*, *Kiesowia*, *Rigidella*, *Ctenobolbina*, and hesitatingly, *Dilobella*, *Pseudostrepula*, *Duhmbergia*, and *Polyceratella*. HESSLAND (1949) followed SCHMIDT in regarding the Tetradellinae as a subfamily of the Hollinidae, and added the following genera to the Tetradellinae: *Glossopsis*, *Ogmoopsis*, and *Steusloffia*.

Glossopsis, *Ogmoopsis*, and *Kiesowia* have been transferred to the Sigmoopsiidae. The other genera mentioned above are retained in the Tetradellidae.

As discussed below, the relationships between the Hollinidae and Tetradellidae are not clear, and the tetradellids are here regarded as constituting a separate family, divided into 3 subfamilies: Tetradellinae, Bassleratiinae, (probably including Ctenentominae), and Piretellinae (probably including Ctenonotellinae).

Subfamily Tetradellinae SWARTZ, 1936.

(Text fig. 3; *13—17*).

Diagnosis: — See p. 263. *Included genera:* — See list p. 266.

Remarks: — This may be rather a central group, showing trends towards other groups. The oldest known beyrichiacean with a velate structure is *Tallinnella primaria* (ÖPIK, 1937) or a closely allied form from the Lower Didymograptus Shale in Norway. The subfamily Tetradellinae includes genera with entire velate structures (probably unspecialized conditions). Dimorphism may be present in that the frill (or part of it) may be convex in some individuals. *Tetradella* and *Dilobella* constitute a group of their own, characterized by the (dimorphic?) development of submarginal loculi between the velate and carinal structures in some individuals. It is hardly necessary, however, to restrict the subfamily Tetradellinae to these two genera alone.

Remarks on the genera *Tetradella* and *Tallinnella*.

(Text fig. 3; *15, 17* — fig. 9 e)

When establishing the genus *Tetradella*, ULRICH (1890) grouped its species into two "sections". The one section was later (1894) awarded generic rank (*Ceratopsis*). The remaining species assigned to *Tetradella* may, however, also be arranged in two groups, as pointed out by SCHMIDT (1941, p. 41); the *quadrilirata* group and the *subquadrans* group. *T. quadrilirata* was designated the type species by ULRICH (1894). This is most unfortunate, since the *quadrilirata* group is a small group of rather abberant forms, whereas the *subquadrans* group represents more that which has become the general concept of the genus, and includes the majority of species.

As will be discussed further below, it is not even certain that the *quadrilirata* group and *subquadrans* group are closely related. For this and other reasons the writer has found it safest and most correct to restrict *Tetradella* to the *quadrilirata* group, although it is regrettable that the *subquadrans* group will then have to be transferred to another genus.

In 1937 ÖPIK errected *Tallinnella* (type species *T. dimorpha* ÖPIK, 1937) and also assigned to it *Beyrichia marchica* KRAUSE, 1889. *Tallinnella* was stated to differ from *Tetradella* (s.1.) mainly in the development of a dimorphic pouch, formed by the frill. The position of *Tallinnella* vis-a-vis *Tetradella* has been discussed in detail by SCHMIDT (1941, p. 38) and HESSLAND (1949, p. 338). SCHMIDT maintains that *T. dimorpha*, *T. marchica*, and probably also *T. grewingki* (BOCK, 1867) are congeneric, but, seeing their likeness to the *subquadrans* group, deems that *Tallinnella* should be regarded as a synonym or subgenus of *Tetradella*. HESSLAND, on the other hand, maintains *Tallinnella* to be a valid genus, and assigns *T. grewingki* to *Tetradella*, considering the sharply raised border of *Tallinnella* as an important distinguishing feature.

The anterior velate pouch of *Tallinnella dimorpha* is not sharply set off from the rest of the frill as is the velate pouch of the Primitiinae. In *T. grewingki* too, the anterior part of the frill may be more or less convex, although it has not been established if this is a dimorphic feature. *Öpikium* and *Rakverella* (probable descendant of the Tetradellinae) show dimorphism in the frill, some individuals having a strongly convex frill. It is interesting to note that the same is true of *Laccochilina* which is an early genus closely related to the Tetradellinae. In the writer's opinion the whole of the *subquadrans* group should be assigned to *Tallinnella*, even if all species do not show such a marked dimorphism as *Tallinnella*. Such a dimorphism appears to be an early phylogenetic feature, and is not characteristic of *Tallinnella dimorpha* alone. The sharply raised border of *T. dimorpha* is in agreement with the accentuated relief as shown by the whole of this species. Furthermore a similar raised border occurs in the earliest known tetradellid species, *T. primaria* (ÖPIK, 1937).

Tallinnella, as defined here, includes forms showing different trends. Forms with crested lobes like *T. lanceolata* (HESSLAND, 1949) (text fig. 9e) point towards *Steusloffia*, whereas forms with swollen lobes and fainter sulci, as *T. teres* (HESSLAND, 1949) may be close to *Hesslandella* gen. n. In the Middle Ordovician there are forms like *T. superciliata* (REED, 1910) with the wide frill restricted to the anterior and ventral areas, thus pointing towards the genera here included in the Piretellinae. *T. scripta* (HARPER, 1947) and *T. bicuneiformis* (HARPER, 1947) are unusual in having L3 connected with the velate ridge by a short ridge. *T. duftonensis* (REED, 1910) may be close to *T. bohemica* (JONES, 1855 or BARRANDE, 1872). *T. subquadrans* may be a rather unspecialized form.

If the *quadrilirata* group has developed from the *subquadrans* group, *Tallinnella* may be regarded as a subgenus of *Tetradella*, but this is, however, uncertain. In some respects the *subquadrans* group (*Tetradella* s.s.) agrees with *Pseudostrepula*. A specimen of *Pseudostrepula kuckersiana acuta* illustrated by BONNEMA (1909, pl. VI, fig. 26) shows an undulation of the area between the carinal and velate ridge which is reminiscent of the pitted area of *Tetradella*. In addition its ridges remind one of *Tetradella quadrilirata* and allied species.

As discussed by SWARTZ (1936, p. 551) *Tetradella* and *Dilobella* may be closely related. It is, however, not necessary to believe that *Tetradella* developed from *Dilobella*, the opposite being even more probable from analogy with *Tallinnella* — *Steusloffia*, where the unisulcate *Steusloffia* appears to have developed from the trisulcate *Tallinnella*. It may be said that *Dilobella* appears to be the unisulcate equivalent of *Tetradella*. As stated by SWARTZ (1936, p. 552) the peculiar terminal loculi seen in these two genera may be of sexual significance, although KAY (1940, p. 265) points out that there seems to be a gradation from forms lacking these pits to those having them well developed.

Tetradella (here restricted to the *quadrilirata* group) thus differs from *Tallinnella* (here including the *subquadrans* group) in having terminal loculi, at least in some individuals and also in having some of the lobes divided into two ridges.

Hesslandella gen. n.
(Pl. 1 fig. 1).

Derivation of name: — This genus is named after Ivar Hessland, who described the type species.

Type species: — *Ctenentoma macroreticulata* HESSLAND, 1949.

Diagnosis: — Unisulcate, straight-hinged ostracods with long sulcus, which may be geniculate. Presulcal node may be developed. Velate ridge entire. Carinal structure and dorsal ridge not developed. Dimorphism not observed.

Remarks: — As discussed below (p. 224) the type species of *Ctenentoma* is based on an internal mould, which probably belongs to *Steusloffia*. Apart from this, a number of different forms have been assigned to *Ctenentoma* because they are unisulcate and have a long sulcus. They are, however, not all closely related. *Hesslandella* is proposed as a new genus for *Ctenentoma macroreticulata* and allied species. It appears to be rather an unspecialized genus. *C. falcatosulcata* HESSLAND, 1949 appears to be close to *H. macroreticulata* and should be included in the same genus. Despite having a more prounced forward swing, *C. canaliculata* HESSLAND, 1949 may probably belong here too, and so may *Aulacopsis nodosa* HESSLAND, 1949, although the latter two species are not well known and may represent larval stages. *Ctenentoma rectangulocarinata* HESSLAND, 1949 (one valve known) is probably a young *Aulacopsis*.

Hesslandella macroreticulata (pl. 1, fig. 1) agrees rather well with *Tallinnella teres* (HESSLAND, 1949) regarding shape, velate ridge, and surface ornamentation, and may represent its unisulcate equivalent. The sulci in *T. teres* are rather faint, and it seems probable that these species are related. For this reason *Hesslandella* is included in the Tetradellinae.

Ceratopsis ULRICH, 1894.

(Text fig. 3; *13—14*).

The type species, *C. chambersi* (MILLER, 1874), is close to *Tallinnella,* especially forms like *T. subquadrans*. Characteristic of *Ceratopsis* is the horn-like development of the dorsal end of L1. It seems that similar horns or spines may be developed in different groups, and that many species which have been assigned to *Ceratopsis* are not congenereric with *C. chambersi*. KESLING (1951, p. 108) states that *Ceratopsis* has some dimorphic species, mentioning *C. playtyceras* and *C. obliquejugate*. These species are here assigned to *Sigmoopsis* gen. n. (cf. p. 205) of the family Sigmoopsiidae. *C. chambersi* and allied forms have no carinal dimorphism as the Sigmoopsiinae and do not have the sigmoidal median sulcus of these forms. No dimorphism is known in *Ceratopsis*; if present, it may be expected in the velate structure. The following genera are now known to produce forms with L1 extending into a horn or spine dorsally; *Ceratopsis*, *Sigmoopsis*, *Dicranella*, *Rakverella*. In *Tallinnella dimorpha* too, L1 may be slightly protruding dorsally.

Polyceratella ÖPIK, 1937.

The position of this genus is uncertain. It has a velate structure, but the carinal ridge is dominant. It may have developed from *Tallinnella* and is tentatively included in the Tetradellinae.

Subfamily Piretellinae ÖPIK, 1937.
(including Ctenonotellinae SCHMIDT, 1941).

(Text fig. 11 a).

Diagnosis: — See p. 263. *Included genera:* — See list p. 267.

Remarks: — The development of the frill is especially characteristic of this group. The frill may be wide but may end more or less abruptly posteriorly and is confined to the anterior and ventral areas (restricted frill). It may show dimorphism, some individuals having a strongly incurved frill.

Most probably the genera included here developed from the Tetradellinae, probably from forms like *Tallinnella superciliata*. HARPER (1947, p. 351) writes that the rounded character of the lobes suggests that a new genus may have to be established for forms like *T. superciliata*. If this was done, this genus would probably be intermediate between the Tetradellinae and the Piretellinae, and may as well be assigned to the one as to the other. Although the Piretellinae have probably developed from the Tetradellinae, it is uncertain whether the Piretellinae represent a strictly monophyletic group, or rather embrace different but probably closely related phylogenetic lines. If this subfamily is split up again, Ctenonotellinae SCHMIDT is available as a subfamily name for *Ctenonotella* and allied.

The Primitiidae may be related to the Piretellinae (cf. p. 226).

Notes on the genera: — ÖPIK (1937, p. 46) erected a family Piretellidae and included in it *Piretella*, *Hesperidella*, *Steusloffia*, *Pseudostrepula*, *Strepula*, and *Rigidella*. THORSLUND (1940, p. 175) doubts the close relationship between *Piretella* and the other genera, stating that *Piretella* differs from these in the general outline of the carapace, in the structure of the false border, and in the presence of a dimorphic ventral pouch. SCHMIDT (1941) drops the family Piretellidae, and transfers its genera to different subfamilies.

The general outline of *Piretella* corresponds favourably well to that of *Steusloffia*, and the difference in structure of the frill in these two genera is not greater than f. inst. between *Chilobolbina dentifera* and *C. decumana*. Furthermore, HESSLAND (1949, p. 355) has later described a new species, *Steusloffia polynodulifera* with a U-shaped crest rather similar to that in *Piretella*. It is therefore mainly the development of a dimorphic ventral pouch which separates *Piretella* from the other genera assigned to the Piretellidae by ÖPIK. The latter genera (here assigned to the Bassleratiinae, cf. p. 220) do not show any (at least not any conspicuous) dimorphism in the velate structures. This fact suggests that *Piretella* has not developed from early Bassleratiinae as *Steusloffia.*

In the writer's opinion *Piretella* may be closely related to forms like *Piretopsis* (HENNINGSMOEN, 1953) and *Rakverella.*

Piretopsis has a ridge similar to that in *Piretella,* but is (faintly) tetralobate, and has an additional ridge on L4. In the earliest known *Piretella* species, *P. margaritata* ÖPIK, 1937, a row of spines appear to occupy a similar position as this additional ridge (see ÖPIK, 1937, pl. XIV, fig. 10). Furthermore *Piretopsis* agrees with *Piretella* in not having an entire frill, and the frill may be convex. *Piretopsis* may be an intermediate stage between *Piretella* and Tetradellinae.

The ridge in *Piretella* is close to that in *Rakverella,* which differs mainly in being more lobe-like. *Rakverella,* too, has the frill confined to the anterior and ventral areas. The writer has in addition seen individuals of *Rakverella* with the frill incurved to form a false pouch very similar to that in *Piretella.*

ÖPIK (1937) describes as *Tetradella? pectinata* and *Tetradella?* sp. aff. *pectinata* some internal moulds, having the test only preserved in the marginal region. These are no doubt internal moulds of *Rakverella bonnemai* ÖPIK, 1937. The spines and ridges in the central area of *Rakverella* explain why this part of the test is often missing. A comparison of an internal mould of *Tetradella? pectinata* (ÖPIK, 1937, pl. XV, fig. 12) with a specimen of *Rakverella bonnemai* (*l.c.*, pl. XV, fig. 10) shows that the internal lobation agrees well with the external pattern, although the tetralobation is better seen in the mould. Furthermore, in *Tetradella?* sp. aff. *pectinata* (*l.c.*, pl. XV, fig. 15) the anterior spine of *Rakverella* is preserved. *Rakverella* displays an unusual feature: the ornamentation of the carapace wall extends well into the frill. The same is seen in *Tetradella? pectinata. Rakverella,* too, appears to have developed from the Tetradellinae, possibly from forms like *Tallinnella superciliata.*

Ctenobolbina duhmbergi, described by ÖPIK (1937, p. 32), most probably represents an early instar of the associated *Piretella margaritata.* The differences between these correspond to those of different instars of *Steusloffia costata,* as described by THORSLUND (1940, p. 176), where the crests first (ontogenetically) are missing to a large extent, then appear as rows of spines, to be developed as full crests in adult stages. *Ctenobolbina duhmbergi* was made the type species of *Duhmbergia* by Schmidt (1941, p. 39). This genus is thus probably a synonym of *Piretella*.

Dicranella may be closely related to *Rakverella*, although they should probably not be regarded as synonyms as suggested by Schmidt (1941, p. 48).

Schmidt (1941) assigns *Dicranella* (including *Rakverella*) together with *Ctenonotella* to a subfamily, Ctenonotellinae, of the Hollinidae. In *Ctenonotella* L2 and L3 are developed as two ridge-like lobes, and the median sulcus is long. It agrees, however, with *Rakverella* in the general shape, and in having a shortened frill. For this reason *Ctenonotella* may be assigned to the Piretellinae, in which case Ctenonotellinae becomes a junior synonym of Piretellinae. *Ctenonotella* may be near to *Tallinnella dubitabilis* (Öpik, 1937), which may be related to *T. superciliata*. *T. dubitabilis* was suggested as a possible synonym of *T. turnbulli* (Reed, 1910) by Schmidt (1941, p. 42). *T. turnbulli* was for good reasons regarded as a synonym of *T. superciliata* by Harper (1947, p. 350).

Öpikium (= *Biflabellum* Öpik, 1937) appears to be related to *Ctenonotella*. L2 and L3 are not developed as nodes, but the sulcus is long, and the frill is of the abruptly ending type (restricted to the anterior and ventral areas), as in *Ctenonotella*. The frill shows dimorphism, being convex in some individuals.

Subfamily Bassleratiinae Schmidt, 1941.

(Text fig. 3; *18—19*. figs. 8a—d, figs. 9a—d).

Diagnosis: — See p. ... *Included genera:* — See list p. ...

Remarks: — This subfamily was erected by Schmidt for the genera *Bassleratia*, *Thomasatia*, *Bellornatia*, and *Raymondatia*, all

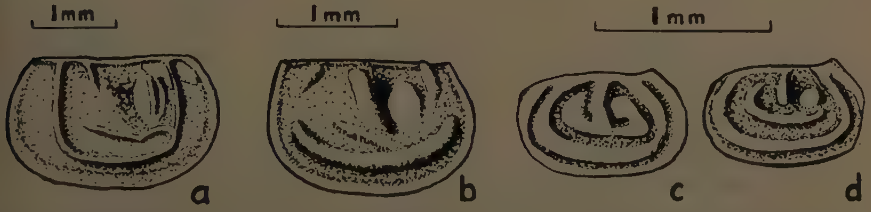


Fig. 8. *a*) *Steusloffia rigida* (after Öpik, 1937, pl. IV, fig. 1), *b*) *Steusloffia europaea* (after Öpik, 1937, pl. III, fig. 11a), *c*) *Bassleratia typa* (after Kay, 1934, pl. 46, fig. 1), *d*) *Bassleratia typa* (after Kay, 1934, pl. 46, fig. 12).

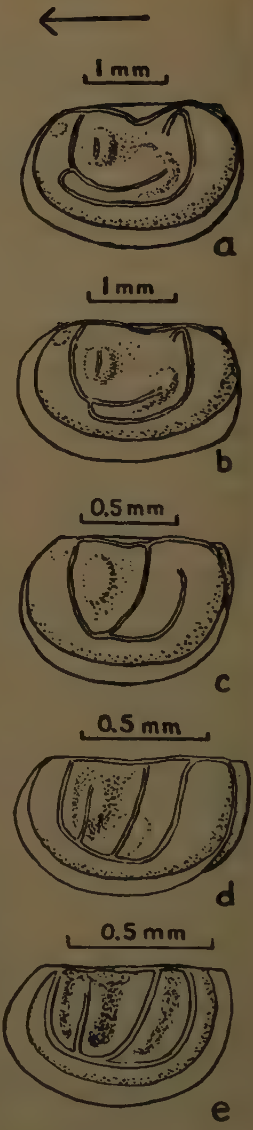


Fig. 9. Morphological series from *Tallinnella* via *Rigidella* to *Steusloffia*. *a*) *Steusloffia costata* (after Thorslund, 1949, pl. XX, fig. 10) Middle Ordovician, *b*) *Steusloffia costata* (after Thorslund, 1940, pl. 3, fig. 6) Middle Ordovician, *c*) *Steusloffia polynodulifera* (after Hessland, 1949, pl. X, fig. 2a) Lower Ordovician. *d*) *Rigidella* cf. *mitis* (cf. pl. 1 fig. 3) Lower Ordovician, *e*) *Tallinnella lanceolata* (after Hessland, 1949, figs. 10, 13). Lower Ordovician.

described by Kay (1934) from North America. Furthermore *Steusloffia* and *Polyzygia* were doubtfully included in this subfamily.

In 1937 Öpik described a new species as *Drepanella europaea* (text fig. 8b). As pointed out by Schmidt (1941, p. 51) this should not be assigned to that genus and was transferred by him to *Bassleratia*. In the writer's opinion it would be better to include it in *Steusloffia*, with which it agrees even more than with *Bassleratia*. *Steusloffia europaea* differs from the other known species of this genus in having somewhat coarser sculpture; some of the crests in other species are developed here rather as ridges, or (dorsal part of C3) even as a node. In the writer's opinion coarser or finer development of the sculpture often does vary in closely related species. *Steusloffia europaea* furthermore agrees very well with the other known *Steusloffia* species in the shape of the valve, the median lobe (L2) being developed as a large elliptical node, etc. It appears also very probable, however, that *Bassleratia typa* (text figs. 8c—d) is related to *S. europaea*. For this reason *Steusloffia* may be included in the Bassleratiinae.

The family Piretellidae was erected by Öpik (1937) for the genera *Piretella*, *Steusloffia*, *Rigidella*, *Pseudostrepula*, *Hesperidella*, and *Strepula*. As discussed above (p. 217), all except *Piretella* have been excluded from the subfamily Piretellinae, and are here included in the Bassleratiinae. *Rigidella*, *Hesperidella*, and *Strepula* appear to be rather closely related to *Steusloffia*. The position of *Pseudostrepula* is perhaps slightly more uncertain.

Origin: — If *Bassleratia* really is related to *Steusloffia*, the origin of the Bassleratiinae is clear. Early forms like *Steusloffia polynodulifera* HESSLAND, 1949 (text fig. 9c) and *Rigidella* are so close to early Tetradellinae that the relationships can hardly be denied. *Tallinnella lanceolata* HESSLAND, 1949 (text fig. 9e) is so close to *Rigidella* that one may be in doubt as to whether it should be placed in the one genus or other. Somewhere, however, the boundary between the Tetradellinae and Bassleratiinae has to be drawn. *T. lanceolata* shows four lobes beneath the crests and three sulci. In *Rigidella* only a semisulcus separates L3 and L4, and in *Steusloffia* even this disappears. The disappearance of a true sulcus S3 is taken as the distinction between early Tetradellinae and early Bassleratiinae. This does not exclude the possibility of enclosing in Bassleratiinae later forms that may have developed a posterior sulcus (S3), and, on the other hand, including in the Tetradellinae species with no S3 but belonging to other trends.

Remarks on *Rigidella* ÖPIK, 1937.

(Text fig. 10, pl. 1 figs. 2—4).

The type species is *Beyrichia mitis* ÖPIK, 1935. According to ÖPIK's description and schematic drawing of the only known specimen, the area corresponding to L4 carries two ridges more or less parallel to the posterior border. The writer is inclined to believe that the posteriormost ridge is a velate structure, a continuation of the frill. The frill is not especially marked off on the schematic drawing, but is clearly visible on the photograph of the specimen (ÖPIK, 1935, pl. I, fig. 5) (here pl. 1, fig. 2). A close study of this photograph reveals that the test is partly missing in the specimen — it is mainly preserved anteriorly and along the frill. If the direction of the frill is continued posteriorly, it is seen that the posteriormost ridge lies in this direction. It would be rather odd if a lobal ridge should be developed so close to the frill or its extention. Furthermore, what at first glance appears to be the connecting ridge between the posteriormost ridge and the ridge behind L3 is most probably the edge of the test, which is preserved along the frill. It is seen that this line is *not* strictly confluent with the posteriormost ridge. A close

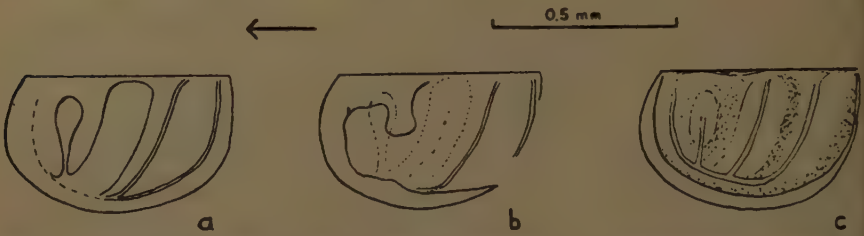


Fig. 10. *Rigidella mitis* (ÖPIK, 1935). Holotype. a) after sketch given by ÖPIK (1935, p. 11). b) The writer's interpretation of the photograph given by ÖPIK (1937, pl. 1, fig. 5). The test is preserved to the left and along the ventral border. c) Reconstruction suggested by the writer.

study further reveals that the ridge behind L3 (this ridge is here assumed to be C4) continues forwards ventrally, just above the line assumed here to be the edge of the test. The forward continuation of C4 joins a row of tubercles (corresponding to C3) on L3. C2 is not preserved. C1 is seen in the dorsal part of L1, where the test is preserved.

The writer believes that the crests (ridges) of *Rigidella mitis* form a normal tetradellid pattern, and that the posteriormost ridge is a continuation of the frill. This explanation is deemed likely by a find of an ostracod corresponding rather closely to *R. mitis* but having the crests as suggested here. If the writer's interpretation of the crests in *R. mitis* is correct, it should probably be assigned to this species. For the time being it may be safer to refer to it as *R.* cf. *mitis*. The material of *R.* cf. *mitis* (pl. 1, figs. 3—4) was collected in drift boulders at Humlenäs, Kristdala in Småland, Sweden by Prof. E. Stensiö of the State Museum of Natural History in Stockholm, who kindly drew the writer's attention to it. The figures of *R.* cf. *mitis* (text fig. 9d; pl. 1, figs. 3—4) may be compared with those of *R. mitis* (text figs. 10a—c). According to the associated fauna these boulders are probably of the same age as the Megalaspis Limestone from which *R. mitis* was described.

Whether the above explanation is correct, or *R. mitis* really has an additional ridge posteriorly, there can be little doubt that *Rigidella* is closely related both to such *Tallinnella* species as *T. lanceolata* (HESSLAND, 1949) and *Steusloffia*. The lobation of *Rigidella* shows an intermediate stage; whereas *Tallinnella* has 4 lobes and 3 sulci and *Steusloffia* has only one sulcus, *Rigidella* still has 4 lobes, but L3 and L4 are separated by a semisulcus only, and there are thus only two real sulci in *Rigidella*. This is the reason why ÖPIK (1935, p. 11) states that *R. mitis* is trilobate, whereas HESSLAND (1949, p. 339) states that it is distinctly 4-lobate.

R. cf. *mitis* may possibly be conspecific with *Rigidella erratica* (KRAUSE, 1889), and it is not improbable that *R. mitis* may turn out to be a synonym of this species, if the writer's interpretation of the latter is correct. One of the valves figured by KRAUSE as belonging to *erratica* (KRAUSE, 1889, pl. II, fig. 8) was separated as a new species, *Rigidella krauseana* by SCHMIDT, 1941. The difference between *R. krauseana* and *R. erratica* is, however, not greater than that seen in the Småland material; the lobe L3 being more or less well developed in its ventral part. It is thus possible that *R. krauseana* is a junior synonym of *R. erratica*. The specimen figured by KRAUSE 1889 in pl. II, fig. 6 may not, however, belong to *R. erratica*. It was given the subspecific name *granulosa* by KRAUSE (1891), but, as suggested by ÖPIK (1935, pp. 10—11) (cf. HESSLAND, 1949, p. 344), may be identical with *Tallinnella grewingki*.

Remarks on *Steusloffia* ULRICH & BASSLER, 1908.

(Text figs. 8a—b, 9a—c).

This genus is of special interest, firstly because THORSLUND (1940) has studied its larval instars and has shown how the crests ontogenetically develop via rows of spines, and secondly because it appears to be an example of a unisulcate form having developed from trisulcate ancestors.

S. polynodulifera occurs in the Lower Ordovician, whereas *S. costata* (LINNARSSON, 1869) occurs in the Middle Ordovician. It is seen that one of the differences between these species is the position of the fusing point of C3 and C4, which phylogenetically moves forwards. This migration continues within the species *S. costata* (cf. THORSLUND, 1948, p. 369). If this trend is hypotethically extended backwards from *S. polynodulifera*, it would result in a form with "normal" tetradellid arrangement of the crests, as in *Rigidella* cf. *mitis* or *Tallinnella lanceolata* (cf. text fig. 9). It seems highly probable that *Steusloffia* has developed from forms like these, with which it agrees in general form, surface ornamentation, type of velate structure, and other details. It may be mentioned here that the area corresponding to the ventral part of L3 may be swollen to form a lobe-like inflation in *Steusloffia*, thus agreeing with the swollen ventral part of L3 in *Rigidella* cf. *mitis*. As long as the lobes are developed, the crests follow their course. When the lobes become confluent, the crests more or less develop their own pattern.

As discussed above, *Drepanella europaea* ÖPIK, 1937 should perhaps be assigned rather to *Steusloffia* instead of *Bassleratia* as suggested by SCHMIDT (1941).

Remarks on *Ctenentoma umbonata* (STEUSLOFF, 1894).

This species is of special interest as it is the type species of *Ctenentoma* SCHMIDT (1941), which again is the type genus of the subfamily Ctenentominae SCHMIDT (1941).

The writer has not seen the holotype and only known specimen of this species. The description by STEUSLOFF is very brief. The specimen was, however, re-examined by KUMMEROW, who states (1924, p. 406) that it is an internal mould (Steinkerne). *Ctenentoma umbonata* is described from a glacial drift boulder and is stated to occur together with i. a. *Conchoprimitia erratica* (KRAUSE, 1891) and *Endoceras angelini* RÜD. As pointed out by STEUSLOFF (1894), this suggests Orthoceras Limestone age (Lower Ordovician).

It is often difficult to refer an internal mould of an ostracod to a certain genus. The only genus, however, with internal moulds exactly like that of *Ctenentoma* and occurring in Orthoceras Limestone appears to be *Steusloffia*. Internal moulds of *S. polynodulifera* HESSLAND, 1949 may be quite like that of *Ctenentoma*, showing the same long median sulcus and rather small but well defined elliptical median node (L2). The frill of *Ctenentoma umbonata* is stated by STEUSLOFF to be strongly convex. Even this has been observed in Norwegian material of internal moulds of *S. polynodulifera*. It is therefore most probable that *Ctenentoma umbonata* is the internal mould of a *Steusloffia* species, possibly *S. polynodulifera* or some closely related species, as f. inst. *S. lineata* KRAUSE (1889).

Many unisulcate beyrichiacean ostracods have been assigned to *Ctenentoma*. Some are here assigned to *Aulacopsis* and *Hesslandella* gen. n., others belong to *Sigmobolbina* gen. n. and related genera. None of these genera have, however, an internal mould like that of *Ctenentoma umbonata*, but the internal mould of *Öpikium* may remind one of it to some extent. *Öpikium*, however, does not have such a well defined median node, and is a later genus (Middle Ordovician).

In the writer's opinion, *Ctenentoma* may be regarded as a younger synonym of *Steusloffia*. This means i. a. that the name Ctenentominae cannot be used for a subfamily. No new name is here proposed, as Ctenentominae becomes a younger synonym of Bassleratiinae, if *Ctenentoma* is a synonym of *Steusloffia*. Schmidt (1941, p. 34) included in the Ctenentominae a number of unisulcate genera; *Ctenentoma*, *Winchellatia*, *Parabolbina*, *Acronotella*, and, tentatively, *Hippa* and *Eoconchoecia*. In the writer's opinion the same degree of sulcation need not necessarily indicate relationships (cf. p. 191), and in this case the assemblage was most probably rather heterophyletic.

Family Primitiidae ULRICH & BASSLER, 1923.

(Text figs. 11b—c).

Diagnosis: — See p. 263. *Included genera:* — See list p. 267.

Remarks: — This family originally included the Primitiinae and the Eurychilininae. Later authors have sometimes added other subfamilies.

The recognition of *Beyrichia strangulata* McCoy, 1851 as the type species of *Primitia* instead of *Beyrichia mundula* Jones, 1855 (cf. Warthin, 1948, p. 645) alters the concept, not only of *Primitia*, but also of the Primitiidae. The writer has had the opportunity of

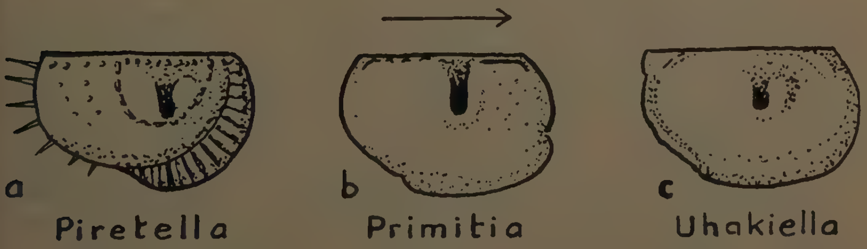


Fig. 11. a) *Piretella margaritata* Öpik, 1937 (based on illustrations given by Öpik, 1937), b) *Primitia strangulata* (McCoy, 1851) (sketch based on type material), c) *Uhakiella kohtlensis* Öpik, 1937 (after Öpik, 1937, pl. III, fig. 9).

studying the type material of *Primitia strangulata.* The results will be published in a special paper. It appears that *Uhakiella* is very close to, or more probably, a synonym of *Primitia* (cf. text figs. 11b—c). SCHMIDT (1941, p. 33) regarded *Uhakiella* as a synonym of *Bromidella*, and was followed in this i. a. by HENNINGSMOEN (1949, p. 416). *Bromidella*, too, may then be regarded as a synonym of *Primitia.* The strong dorsal ridge or rather swelling of *Bromidella* is, however, rather unique, and it may be better to retain *Bromidella* as a separate genus, undoubtedly closely related to *Primitia.* It appears that *Chilobolbina* is also related to *Primitia.* As discussed below, the family Primitiidae is here restricted to these genera with a dimorphic velate pouch (false pouch); *Primitia*, *Uhakiella*, *Bromidella*, and *Chilobolbina.*

Bromidella and *Chilobolbina* have hitherto been assigned to the Eurychilininae. If this group is monophyletic, this would involve all the eurychilinids being related to *Primitia*, and Eurychilininae could be regarded as a synonym of Primitiidae, or at least included as a subfamily in the Primitiidae. The eurychilinids do not produce such a well defined ventral pouch as the Primitiidae. It is, however, quite possible that the Primitiidae (earliest known occurrence: Middle Ordovician Kukruse formation) have developed from the eurychilinids (earliest known occurrence: Lower Ordovician), especially as the eurychilinids appear to tend towards forming a well-defined false pouch. There is, however, also the possibility that the Primitiidae developed from the Tetradellinae, possibly via *Piretella* or forms allied to *Piretella.* The Primitiidae agree with the Piretellinae in usually having the frill restricted to the anterior and ventral areas, and in forming a false pouch as a dimorphic feature (cf. text fig. 11). A form such as *Chilobolbina decumana* (BONNEMA, 1909) is rather similar to *Piretella*, save for the absence of the piretellid ridge. Furthermore the Primitiidae develop a dorsal ridge as in *Piretella*, whereas the eurychilinids do not develop such a ridge (excepting the early genus *Laccochilina*). The primitiids and eurychilinids may thus represent separate off-shoots (more or less along the same lines of development) from the Tetradellinae. For this reason it appears to be best to regard the Primitiidae and Eurychilinidae as separate families.

The Euprimitiinae have tentatively been assigned to the Eurychilinidae (cf. p. 228).

Family Eurychilinidae ULRICH & BASSLER, 1923.

Diagnosis: — See p. 263. *Included genera:* — See list p. 267.

Remarks: — This family is here defined to include the subfamily Eurychilininae, and, tentatively, the subfamilies Euprimitiinae and Primitiopsiinae. The family Eurychilinidae corresponds then to a certain extent to the family Primitiidae in its earlier sence.

Subfamily Eurychilininae ULRICH & BASSLER, 1923.

Diagnosis: — See p. 263. *Included genera:* — See list p. 267.

Remarks: — A number of genera have been included in the Eurychilininae, namely *Apatobolbina*, *Apatochilina*, *Bromidella*, *Chilobolbina*, *Craspedobolbina*, *Eurychilina*, *Laccochilina*, *Neochilina*, and *Platybolbina* (=*Platychilina*). As stated above, *Bromidella* and *Coelochilina* with a velate false pouch, may be close to *Primitia* and have been included in the Primitiidae. *Craspedobolbina*, too, develops a dimorphic pouch (egg-shaped). *Craspedobolbina* is described from a drift boulder in N. Germany. The associated fauna suggests that this form is of upper Ordovician age. It has many features in common with *Beyrichia*, and whether it should be assigned to the Primitiidae or Beyrichiidae depends on the pouch being a velate false pouch or a pouch opening into the main cavity of the carapace (as in the Beyrichiidae) or not. Much the same applies to the Silurian genus *Apatobolbina*. As remarked by ULRICH & BASSLER (1923, p. 522), its »pouch looks so much like that of *Beyrichia* and extends so far up on the slope of the ventral convexity of the valve as to suggest that in this type also it opens on the inner side of she contact margin«. It may be added that this applies to the Silurian species assigned by ULRICH & BASSLER (1923) to *Chilobolbina*. These species may be transferred to *Apatobolbina*, which will then include forms with or without sulcal pit. In these species it is even more clear that the frill continues between the pouch and the margin (cf. ULRICH & BASSLER, 1923, pl. XXXVII, figs. 7, 11). Until further investigations clarify the type of pouch in *Craspedobolbina* and *Apatobolbina*, the writer is inclined to believe that they may be beyrichiids. It may be recalled that the rather similar Silurian genus *Dibolbina* was already claimed by ULRICH & BASSLER (1923, p. 658) to be a beyrichiid.

The position of the Devonian genus *Neochilina* is rather uncertain. As suggested by SWARTZ (1936, p. 551) it is removed from the Eurychilinidae.

This leaves *Eurychilina, Apatochilina, Coelochilina, Laccochilina*, and *Platybolbina* as probable members of the Eurychilininae.

The American species of *Eurychilina* have a peculiar frill with a small ridge subparallel to the edge along the greater part of the inner side of the frill. In the writer's opinion the genus should be restricted to this group. This feature has not been described from any of the other genera assigned to the Eurychilininae. It seems probable, nevertheless, that genera like *Laccochilina*, *Coelochilina*, and *Apatochilina* are closely related to *Eurychilina*, although there is always the danger that they may represent different trends developing in the same direction, especially with such rather smooth forms. Some species assigned by HESSLAND (1949) to *Eurychilina* may be transferred to *Laccochilina*; since they do not have the typical *Eurychilina*-frill. There seems to be an even transition of forms from these species to the type species of *Laccochilina*.

Platybolbina corresponds rather well with the other genera retained here in the Eurychilininae. *Öpikella* may probably be closely related to *Platybolbina*. The two species erected by THORSLUND (1940, pp. 181—182), *Ö. tvaerensis* without a frill and *Ö. asklundi* with a shortened, incurved frill represent most probably one dimorphic species. Apart from the loss of the frill in one dimorph, this genus agrees very well with *Platybolbina*. There is rather a short step from *Öpikella* to aparchitids, namely, the loss of the frill in the other dimorph as well and it is possible that at least some forms assigned to the Aparchitidae may have developed from Eurychilininae via forms like *Öpikella*.

?Subfamily Euprimitiinae HESSLAND, 1949.

Diagnosis: — See p. 263. *Included genera:* — See list p. 268.

Remarks: — The subfamily Euprimitiinae is not well known. It agrees apparently with the Eurychilininae in developing uni- or nonsulcate forms, in often having a pitted surface, and in (at least some forms) having a velate structure. The velate structure shows dimorphism as the Eurychilininae, but in the Euprimitiinae the dimorphism is usually confined to the antero-ventral part of the velate structure. The Euprimitiinae do not, however, develop a false pouch as the Primitiidae. The Euprimitiinae are here tentatively included in the Eurychilinidae.

The type species of *Euprimitia*, *E. sanctipauli* (Ulrich, 1894) has been described in detail by Kay (1940, p. 252), who points out that it is dimorphic. In some individuals the border is depressed, in others forming a flange obscuring a channelled area. *E. labiosa* (Ulrich, 1894) as described by Kay (1940, p. 252) is also dimorphic. Both dimorphs have a narrow frill, but in the one dimorph it is wider antero-ventrally, where it is also situated further from the margin. This part of the frill corresponds most probably to the flange in *E. sanctipauli*, this flange then being a velate structure.

As demonstrated by Kay (1940, p. 262), the type species of *Primitiella*, *P. constricta* Ulrich, 1894, also shows dimorphism. The anterior end is depressed in some individuals, whereas it is steeply raised in others. It may be compared with the dimorphism in *E. sanctipauli*. Whereas *E. labiosa* has a velate frill in both dimorphs, being wider and situated further from the margin antero-ventrally in the one dimorph, *E. sanctipauli* has no velate structure in the one dimorph, but an anteroventral flange in the other. In *Primitiella constricta* both dimorphs have no distinct velate structure, but in the one dimorph the anterior end is steeper and higher, as in *Euprimitia*. It is probable that *Primitiella* is related to *Euprimitia* and may have developed from *Euprimitia* through the loss of any distinct velate structures. If so, *E. sanctipauli* is intermediate between *E. labiosa* and *Primitiella constricta* regarding the velate structure.

Haploprimitia is not very well known, and its type species, *H. minutissima* Ulrich, 1894, has not been recognized in later collec-ions (Kay, 1940, p. 248). It has no velate structure, and may possibly be related to *Primitiella*. The same is true of *Laccoprimitia*, at least f *L. fillmorensis* (Ulrich, 1894) (as described by Kay, 1940, p. 248) s congeneric with the type species. *Ectoprimitia* described by Bouček 1936) as a subgenus of *Haploprimitia* is probably not closely related o this, and its position is rather uncertain. *Halliella*, *Hallatia*, *Pyxiprimitia*, and *Punctoprimitia* are probably not related to the Euprimitiinae (cf. p. 248).

No dimorphism is described from the type species of *Euprimites*, *E. reticulogranulata* Hessland, 1949 (type material only two cara-aces and two valves). *Ctenobolbina suecica* Thorslund, 1940 may be congeneric. This species shows a dimorphism very similar to that of *Euprimitia labiosa*. The main differences is that the widened part of the velate structure is situated more ventrally in *Euprimites suecica*. *Euprimitia minor* Thorslund, 1940 (transferred to *Euprimites* by Hessland, 1949) may be conspecific with *E. suecica*, the latter representing adult individuals. It is thus possible that *Euprimites* is related to *Euprimitia*, as suggested by Hessland (1949, p. 242). No doubt the type species of *Euprimites* is closely related to early Tetradellinae and *Laccochilina*, and its narrow velate structure may be compared to that of *Hesslandella* and certain species of *Tallinnella*.

?Subfamily Primitiopsiinae Swartz, 1936.

Diagnosis: — See p. 263. *Included genera:* — See list p. 268.

Remarks: — *Primitiopsis* resembles *Euprimitia* in general outline, in lobation, in developing a dorsal ridge, and in having a velate false border. Whereas the dimorphic part of the velate structure is situated antero-centrally in *Euprimitia*, the velate false pouch of *Primitiopsis* is usually believed to be situated posteriorly. Good material of different growth stages of the type species, *P. planifrons* Jones, 1887 from Mulde, Gotland, Sweden shows that the sulcal pit migrates towards the end opposite to that bearing the false pouch in some adult individuals. It appears reasonable to assume that the pit migrates forwards during the ontogenetical development, just as the muscle scar migrates forwards in recent ostracods (cf. Claus, 1886). This supports the view that the false pouch of *Primitiopsis* is situated posteriorly.

Sulcicuneus was described by Kesling (1951a) as an additional primitiopsid genus. It agrees, however, very well with contemporaneous hollinids, and as its posterior false pouch may be a marginal rather than a velate structure, it is tentatively assigned to the Hollinidae.

Family Aparchitidae JONES, 1901.

Diagnosis: — See p. 263. *Included genera:* — See list p. 268.

Remarks: — A number of non-sulcate, more or less smooth genera have been included in this family. Some are transferred here to other genera.

It is possible that at least some of the forms assigned to this family developed from Eurychilinidae via forms like *Öpikella* (cf. p.228).

In any case, *Aparchites* shows traces of a velate structure and should be included in the Beyrichiacea and not in the Leperditiacea. In the type species, *Aparchites whiteavesi* JONES, 1889, there is a distinct velate ridge. In many other forms assigned to *Aparchites*, as *A. fimbriatus* ULRICH, 1892 and *A. granilabiatus* ULRICH, 1892 the velate structure is developed as a row of spines.

Leperditella (and thus the Leperditellinae) may, however, possibly belong to the Leperditiacea (cf. p. 250). The same may be true of *Eridoconcha*, *Schmidtella*, and *Paraschmidtella* of the new subfamily Eridoconchinae, and *Conchoprimitia* of the new subfamily Conchoprimitiinae (cf. p. 250).

Paraparchites, *Antiparaparchites*, *Proparaparchites*, *Microparaparchites*, and *Pseudoparaparchites* have usually been included in the Aparchitidae. As discussed below (p. 243) they are here transferred to the Kloedenellidae, where it has already become usual to place *Sansabella*.

This leaves but a few genera in the Aparchitidae; besides the type genus there are only *Neoaparchites*, *Punctaparchites*, and *Macronotella*. The writer agrees with SCHMIDT (1941) and HESSLAND (1949) who remove *Macronotella* from the Kirkbyidae. The relationships between *Aparchites* and *Macronotella* are, however, not fully known, and it appears best to assign *Macronotella* (and for the same reason *Punctaparchites* and *Neoaparchites*) only tentatively to the Aparchitidae. As ostracods of the rather simple *Aparchites* type may have developed in different groups, and no doubt have done so, it is not more than could be expected that several of the genera assigned to the Aparchitidae would not, on closer examination, turn out to be closely related to *Aparchites*.

Family Drepanellidae ULRICH & BASSLER, 1923.

Diagnosis: — See p. 263. *Included genera:* — See list p. 268.

Remarks: — The subfamily Drepanellinae ULRICH & BASSLER, 1923 was awarded family rank by SWARTZ (1936). SCHMIDT (1941) included four subfamilies in this family; Drepanellinae, Ulrichiinae (= Bolliinae), Aechmininae, and Bassleratiinae. The Bassleratiinae are here excluded from the Drepanellidae and transferred to the Tetradellidae. The Bassleratiinae differ from the Drepanellidae in a number of features, i. a. in having a velate structure, whereas the submarginal ridge of the Drepanellidae appears to be a carinal structure, or at the best, a fused carinal and velate structure.

The Drepanellidae do not seem to develop either false pouches or pouches as swelling of the carapace wall. It is, however, possible that at least some of the forms of the Drepanellidae are dimorphic. SWARTZ & SWAIN (1941, p. 421) note that there is a considerable variation in the convexity of the postventral third of *Bollia diceratina* SWARTZ & SWAIN, 1941, and suggest that this may be due to sexual dimorphism.

Subfamily Drepanellinae ULRICH & BASSLER, 1923.

Diagnosis: — See p. 264. *Included genera:* — See list p. 268.

Remarks: — ULRICH & BASSLER (1923) established a subfamily Drepanellinae of the Zygobolbidae and included in it *Drepanella, Scofieldia, Mesomphalus,* and *Drepanellina.* The writer quite agrees with SWARTZ (1936) who transferred the latter two genera to the Kloedeninae (= Beyrichiinae) due to their subventral dimorphic pouches, and removed the drepanellids from the Zygobolbidae. It may be noted that *Mesomphalus* and *Drepanellina* differ from the Drepanellinae again in having a velate ridge. SWARTZ (1936) added *Jonesella* and *Bollia* to the Drepanellinae, and tentatively also *Ulrichia* and *Polyzygia,* whereas SCHMIDT (1941) included the following genera; *Drepanella, Scofieldia, Jonesella, Cornulina,* and *Lindsayella.*

If *Drepanella bigeneris* ULRICH, 1894 is a true member of *Drepanella* (and this seems probable), *Drepanella* appears to be close to *Bollia.* As pointed out by ULRICH & BASSLER (1908, p. 312) it is really difficult to give sufficient reasons for excluding *D. bigeneris* from *Bollia.* It may be remembered that the large size of *Drepanella* (about 2.5 mm long) is also attained by representatives of *Bollia,* as *B. americana zygocornis* SWARTZ, 1936.

Drepanella is, however, not sufficiently known. In a personal communication (2. Nov. 1950) Dr. B. KELLETT NADAU writes that "many figures of *Drepanella* are very misleading. They appear to be flat, with rather sharp, higly raised ridges rising abruptly as if stuck on to this flat surface. Instead, the surface is undulating and there is a deep, subcentrally located dorsal sulcus." It seems therefore best at present to restrict the subfamily Drepanellinae to *Drepanella* and *Scofieldia,* assigning *Bollia* to the Bolliinae.

?Subfamily Bollinae Bouček, 1936.
(including subfamily Ulrichiinae Schmidt, 1941).

Diagnosis: — See p. 264. *Included genera:* — See list p. 268.

Remarks: — Bouček established this family in 1936 and referred it to the Primitiidae. He included in it *Bollia, Placentula, Jonesella,* and *Bolbibollia,* whereas *Ulrichia* was retained in the Primitiinae. Swartz (1936) included *Bollia,* and tentatively also *Ulrichia* in the Drepanellidae. Schmidt (1941) erected a new subfamily Ulrichiinae, and included in it *Ulrichia, Pseudulrichia, Pyxiprimitia, Bollia,* and tentatively *Jonesites* (= *Placentula*), *Halliella,* and *Hallatia.* If *Bollia* and *Ulrichia* are included in the same subfamily, the writer agrees with Přibyl (1951) who retains the name Bolliinae, regarding Ulrichiinae as a later synonym. There exists, however, the possibility that *Ulrichia* is not so closely related to *Bollia,* in which case Ulrichiinae may be revived for *Ulrichia* and allied genera.

Remarks on the genera: — *Bollia* has long been a collective name for forms with a U-shaped ridge (L2—L3). Several species earlier assigned to this genus have lately been transferred to new genera. The type species of *Bollia* is *B. uniflexa* Jones & Holl, 1886 (not *B. bicollina* Jones & Holl, 1886, cf. Warthin, 1948), and it is possible that the genus is still too heterogenous. *Bollia,* especially early members like *B. subequata* Ulrich, 1894, agrees rather closely with *Ulrichia* in the general shape, the swollen submarginal ridge, and the two nodes, which may be only indistinctly joined by a ridge in some species of *Bollia.* It may be mentioned here that *Ulrichia* seems to develop some very persistent types. *U. paupera* Schmidt, 1941 from the Ordovician is remarkably like the Devonian form *U. pluripuncta* Swartz, 1936. Also other bolliid genera appear to develop rather stable forms.

Maratia may be close to *Bollia* and *Ulrichia. Parenthatia,* which has a similar submarginal ridge, but no nodes is probably related, too. In *Saccelatia* the submarginal ridge may be developed as in the above genera, or reduced to short alate processes, or may be even missing. *Warthinia,* although having additional nodes, may be near to *Ulrichia,* and was regarded as a synonym of *Ulrichia* by Schmidt (1941). *Pseudulrichia* was established by Schmidt (1941), who placed it close to *Ulrichia.* This is no doubt true of the species described by Schmidt. As type species he selected, however, *Leperditia bivertex*

ULRICH, 1879. It is unfortunately not well known, but appears to belong to the Bolliinae. *Pseudulrichia* has the two nodes of *Ulrichia*, but a submarginal ridge is not separated. *Parulrichia*, too, may be closer to *Ulrichia* and *Pseudulrichia*, than to *Aechmina* (as suggested by SCHMIDT, 1941). *Crescentilla* (cf. SCHMIDT's redescription in 1941) may be related to *Parulrichia*. *Richina* appears to be related to *Pseudulrichia*.

The following genera may be tentatively included in the Bolliinae; *Zygobolboides*, *Jonesella*, *Vogdesella* (= *Melanella*), *Kinnekullea*, *Jonesites* (= *Placentula*), and *Saccelatia*.

? Subfamily Aechmininiae BOUČEK, 1936.

Diagnosis — See p. 264. *Included genera:* — See list p. 269.

Remarks: — In this subfamily BOUČEK included *Aechmina* and *Paraechmina*. A few months later SWARTZ (1936) independantly erected a family Aechminidae for the same two genera. SCHMIDT (1941) added *Parulrichia* and *Crescentilla*, and, tentatively, *Aechminaria*. *Parulrichia* and *Crescentilla* are here assigned to the Bolliinae. *Aechminaria* appears, however, to be near to *Paraechmina*, having i. a. the same little pit in front of the base of the spine. This applies also to the related *Lindsayella* and the closely allied *Waldronites* (= *Cornulina*), probably a synonym of *Lindsayella*. *Ardmorea* is also possibly related to *Aechmina* (cf. COOPER, 1946, p. 40).

Aechmina bigeneris and *A. spinoterminatus* described from the Devonian by SWARTZ (1936) are interesting because they have the submarginal spine-row of *Aechmina* (no ridge), and the pit of *Paraechmina*.

? Family Acronotellidae SWARTZ, 1936.

Diagnosis: — See p. 264. *Included genera:* — See list p. 269.

Remarks: — The type genus, *Acronotella*, is insufficiently known, and its relationships are uncertain. SWARTZ (1936) established the "provisional" family Acronotellidae and included in it also *Monoceratina*, *Mooreina*, and *Eoconchoecia*, all having a pair of ventral spines. TEICHERT (1937a, p. 113) includes two more genera, *Tricornina* and *Monoceratella*, but believes that "the genera of this "family" are derived from different stocks and do not represent a natural assemblage of genetically related forms", and regards (1937b, p. 53) the ventral spine as a recurrent homeomorphic feature. Triebel (1941, p. 368) expresses much the same views, and maintains that this group of genera is, at the best, an ecological group. The writer agrees with Teichert and Triebel, and removes *Monoceratina* (cf. p. 259), as well as *Mooreina*, and *Eoconchoecia* from the Acronotellidae. *Monoceratella* agrees with *Acronotella* in also having a produced anterior cardinal angle, and is tentatively retained in the Acronotellidae.

If *Acronotella* is related to *Tricornina*, here assigned to the Alanellidae, Acronotellidae may become a synonym of Alanellidae (cf. p. 248).

If *Acronotella* can be shown to be related to *Winchellatia*, as suggested by Schmidt (1941, p. 34), the Acronotellidae and Sigmoopsiidae nov. may be synonyms. This is, however, not very likely, and it is not even certain that the Acronotellidae belong to the Beyrichiacea.

Later families.

These are the post-Ordovician families. Besides the Paleozoic families discussed in this paper, the recent family Punciidae Hornibrook, 1949 may, as suggested by its author (1949, p. 471), possibly belong here. Unfortunately its two genera, *Puncia* and *Manawa*, both erected by Hornibrook (1949), are only known from separated valves without traces of appendages.

Family Beyrichiidae JONES, 1894.

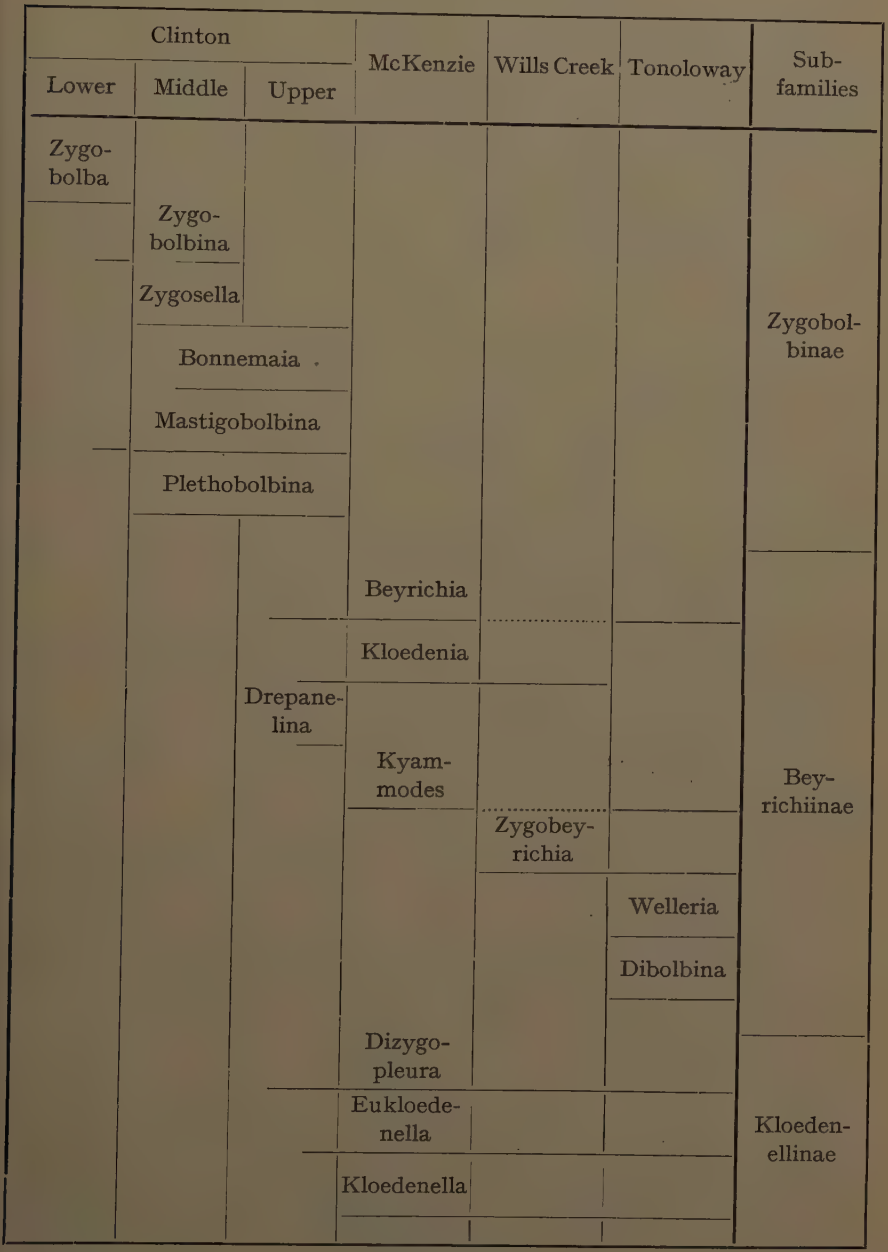
Diagnosis: — See p. 264. *Included genera:* — See list p. 269.

Remarks: — Characteristic of this family is especially the subventral pouch (or swelling) which is not formed by the frill as in the Primitiidae, but by the carapace wall itself and opens into the main cavity. Swartz (1936) did not distinguish between a false, extraneous pouch and the pouch of the *Beyrichia* type and included the Eurychiliniae in the Beyrichiidae. The Beyrichiidae are restricted here to those forms developing an antero-ventral dimorphic pouch as a swelling of the carapace wall. On the other hand, all forms with this type of dimorphism are included in the Beyrichiidae, thus also the zygobolbids. The family Zygobolbidae was established by Ulrich &

BASSLER (1923, p. 530) for the subfamilies Zygobolbinae, Kloedeninae, and Drepanellinae. The beyrichiid genera assigned to the Drepanelliae, namely *Drepanellina* and *Mesomphalus*, were transferred to the Beyrichiidae because of their beyrichiid pouch already by SWARTZ (1936, p. 553). *Kloedenia* is very close to *Beyrichia*, and in the writer's opinion the Kloedeninae may thus be regarded as a synonym of the Beyrichiinae. The Zygobolbinae are undoubtedly close to the Beyrichiinae, and are here regarded as constituting a subfamily of the Beyrichiidae, which will then be a well-defined, and, as it seems, natural unit. *Mastigobolbina* and *Plethobolbina* were included in the Kloedeninae (here = Beyrichiinae) by ULRICH & BASSLER (1923) but are here transferred to the Zygobolbinae.

The range chart shows the vertical distribution of the beyrichiid genera as recorded by ULRICH & BASSLER (1923) from the Silurian sequence in Maryland. ULRICH & BASSLER (1923, p. 651) described *Beyrichia emaciata* from the Lower Clinton. It is based on a single, imperfectly preserved specimen, which in the writer's opinion may not be a *Beyrichia* species but possibly a zygobolbid. This involves that whereas the Zygobolbinae range from the Lower to the Upper Clinton, the Beyrichiinae seem to appear later, ranging from the Upper Clinton and upwards. The vertical distribution of beyrichiids has not been comparatively so well studied in other areas, but it seems as if true *Beyrichia* species also occur in the lowermost Silurian beds. Anyhow, the early Beyrichiinae are very close to especially the the earliest Zygobolbinae. *Beyrichia* may be rather close to the very similar *Mastigobolbina incipiens* group. It is interesting that this group develops a velate frill, as do some *Beyrichia* species, not only a velate ridge as the other Zygobolbinae. *Zygobolba* is the earliest genus of the Zygobolbinae (and the Beyrichiidae) in the Maryland sequence. The remaining zygobolbid genera undoubtedly have developed directly or indirectly from *Zygobolba*. In the writer's opinion the origin of the Beyrichiidae is, however, still uncertain. When searching for the ancestors of the Beyrichiidae, it may be an idea to look for forms also resembling *Zygobolba*. Even if the pouch of the Beyrichiidae does not correspond to the dimorphic velate structures of the Primitiidae or Eurychilinidae, it is not of course improbable that the Beyrichiidae may have developed from one of these groups, or possibly from the Tetradellidae. The Beyrichiidae agree with these families in having a velate ridge or frill.

It may be recalled that the pouch of the Beyrichiidae most



Range chart.

Stratigraphical range of Beyrichiidae (Zygobolbinae and Beyrichiinae) and Kloedenellidae (Kloedenellinae) in the Silurian sequence in Maryland and Pennsylvania, based on data published by Ulrich & Bassler (1923). The Lower Clinton *Beyrichia emaciata* has here been removed from *Beyrichia* (p. 236).

probably served as a brood pouch. Hessland (1949, p. 124) and Spjeldnæs (1951, p. 748, pl. 103, figs. 1—2) have observed larval carapaces in the pouch. It may be noted that in the present terminology the carina of Spjeldnæs is the velate ridge, whereas the velum of Spjeldnæs is the marginal spine-row. The orientation of the carapace is here the reverse of that applied by Spjeldnæs and in agreement with that applied i. a. by Swartz (1936) and Kesling (1951).

Subfamily Beyrichiinae Jones, 1894.

Diagnosis: — See p. 264. *Included genera:* — See list p. 269.

Remarks: — *Kloedenia* is so close to *Beyrichia* that the Kloedeninae are regarded here as a synonym of the Beyrichiinae. This subfamily will then include the genera *Beyrichia*, *Kloedenia*, *Welleria*, *Kyammodes*, *Zygobeyrichia*, *Treposella*, and *Dibolbina*. Furthermore Swartz (1936, p. 553) added *Drepanellina* and *Mesomphalus* because of their pouch, and *Bolbibollia* should be added for the same reason. As discussed above (p. 227), *Apatobolbina* may belong here, too.

A number of species not developing any dimorphic pouch of the beyrichiid type are no longer included in *Beyrichia*. *Beyrichia* has for a long time been a collective name for disulcate forms of the type S1—S2. No Ordovician species appear to belong to *Beyrichia*, nor many post-Silurian specis such as *B. contracta*, *B. sagitta*, and *B. placida* described by Cooper (1941) from the Upper Mississippian of Illinois. No dimorphic pouch (or swelling) has been described in these species, which appear to be near to *Chesterella* and at least most probably belong to the Kloedenellidae. The latest known Beyrichiinae (and Beyrichiidae) appear to be Devonian species of *Beyrichia* (as *B. latispinosa* Přibyl, 1951) and the Devonian *Treposella* and *Mesomphalus*. It appears that the Beyrichiinae are restricted to the Silurian and Devonian.

Subfamily Zygobolbinae Ulrich & Bassler, 1923.

Diagnosis: — See p. 264. *Included genera:* — See list p. 269.

Remarks: — This subfamily was originally established for the genera *Zygobolba*, *Zygobolbina*, *Zygosella*, and *Bonnemaia*. *Mastigobolbina* and the closely related *Plethobolbina* are removed here from the Kloedeninae (here = Beyrichiinae) to the Zygobolbinae. Thanks to the paper on Silurian ostracods by ULRICH & BASSLER (1923), transitional forms are known between all these genera. Rather characteristic of the Zygobolbinae is the U-shaped ridge. In *Mastigobolbina* the posterior part of this ridge (the flagellum of ULRICH & BASSLER, 1923) is often whip-lash-like. There are, however, all transitions from this to the type found in other zygobolbids. As discussed above (p. 227), *Craspedobolbina* may belong to the Beyrichiidae. As it has a ridge resembling that of the Zygobolbinae, it is tentatively assigned to this subfamily. The Beyrichiinae may be rather close to the Zygobolbinae (cf. p. 236), and some of the early representatives, as *Beyrichia lakemontensis* ULRICH & BASSLER, 1923, show traces of a ridge similar to the U-shaped ridge of the Zygobolbinae. The Kloedenellidae may possibly be related to the Zygobolbinae.

Family Hollinidae SWARTZ, 1936.

Diagnosis: See p. 264. *Included genera:* See list p. 270.

Remarks: — SWARTZ (1936) included *Ctenobolbina* in the Hollinidae, and SCHMIDT (1941) and HESSLAND (1949) regarded the Tetradellinae, Ctenentominae, and Ctenonotellinae as subfamilies of the Hollinidae. In the writer's opinion the supposed close relationships between the hollinids on the one side and the tetradellids and *Ctenobolbina* on the other are based on false presumptions (not meaning, however, that such relationships may not yet be traced). The affinity between hollinids and Ordovician ostracods has been misunderstood partly because many hollinids have been assigned to *Ctenobolbina*, a typical "sack genus" in earlier days, whereas on the other hand Ordovician forms probably belonging to the Eurychilinidae have been assigned to the hollinid genus *Parabolbina*. The Trenton species assigned by KAY (1940) to *Parabolbina* are probably eurychilinids. They lack the hollinid spur and do not show any of the features peculiar to the hollinids, such as type of frill and specialized 3. lobe. The Devonian species assigned to *Ctenobolbina* by KESLING & MCMILLAN (1951) are rather simple hollinids ("effaced lobation") but do show hollinid features as well developed spur and very marked dorsal swelling of the 3. lobe. These species should be regarded as true hollinids and may be transferred to the genus *Parabolbina*, or be allowed a new genus.

When *Ctenobolbina* is restricted to the type species and closely allied forms (cf. p. 211), it is seen that *Ctenobolbina* differs from the hollinids in many respects, and the writer strongly doubts that there is any close relationship between them. *Ctenobolbina* (and the Sigmoopsiinae as a whole) has only a narrow and entire frill, shows no swelling of the dorsal end of the 3. lobe and does not develop a hollinid spur.

It would appear from the above that the Hollinidae are restricted to the Devonian and later systems. There is, however, at least one certain Silurian hollinid, namely *Parabolbina auricularis*, redescribed below.

The Devonian *Hanaites*, described as a subgenus of *Halliella* by POKORNÝ (1950) is a hollinid and appears to be very close to *Proplectrum*.

Sulcicuneus porrectinatum was described as a new primitiopsid ostracod from the Devonian of Michigan by KESLING (1951a). It has a posterior extraneous chamber, resembling that of *Primitiopsis*, but agrees otherwise remarkably well with contemporaneous hollinids. Its general outline and lobation may be compared f. inst. with those of *Subligaculum recurvisulcatum* KESLING & MCMILLIAN (1951, pl. 2, figs. 5—12). Furthermore, the ridge-like frill of *Sulcicuneus* appears to be restricted to the anterior and ventral border areas, as in the hollinids. The extraneous chamber appears to be formed by the marginal structure, and not by the velate structure as in *Primitiopsis*. The dorsal ridge of *Primitiopsis* is missing in *Sulcicuneus*. It is thus possible that *Sulcicuneus* should be included rather in the Hollinidae than in the Primitiopsiinae.

Redescription of *Parabolbina auricularis* (JONES, 1887).
(Pl. 1, figs. 5—8.)

Type data: — Holotype is the specimen described and figured by JONES (1887, p. 408, pl. XIII, figs. 10a—c) from the Wenlock at Ironbridge, Severn, England. It is apparently of the male type.

Material described here: — This consists of some 60 well preserved valves and carapaces (including larval forms) from the Wenlock at Mulde, Gotland, Sweden. The material belongs to the Paleozoological Department of the Swedish State Museum, Stockholm. *Parabolbina auricularis* was recorded from this locality already by CHAPMAN (1901, p. 150).

Description: — Carapace subrectangular, somewhat elongate, with slight but conspicuous forward swing. Dorsal border straight, free border curved, both cardinal angles slightly obtuse. In the hinge a list in the left valve fits into a corresponding groove of the right valve. Median sulcus well developed, expanding ventrally, mostly in a forward direction. Both the pre-sulcal lobe (L1 + L2) and the post-sulcal lobe (L3 + L4) are inflated, the posterior mostly so. The frill is dimorphic. Female type: — The narrow frill extends from somewhat below the anterior cardinal angle to a point below and well behind the sulcus and therefore not along the posterior margin. The frill ends in a spine or spur pointing backwards. Male type: — The frill is discontinuous, and consists of a short anterior part along the lower half of the anterior border and a longer part along the ventral border. The latter part ends in a spine similar to that of the female type. In larval forms the type of frill mostly resembles the male type. It consists of two parts, but both are very short, almost spine-like. The marginal structure is tuberculate. The surface of the valves is granulose, except the sulcus and the frill. The adult specimens are about 0.9 mm long.

Remarks: — This species appears to be the earliest described undoubtful hollinid. It was described as *Bollia auricularis* but has lately been usually assigned to *Ctenobolbina* or *Ctenentoma*. Its type of velate structures and dimorphism and the ventrally expanded sulcus are typically for hollinids, and it is here transferred to *Parabolbina*.

Family Kloedenellidae ULRICH & BASSLER, 1908.

Diagnosis: — See p. 264. *Included genera:* — See list p. 270.

Remarks: — This family is regarded here as including the subfamilies Kloedenellinae, Beyrichiopsiinae nov., and Glyptopleurinae. No true kloedenellids appear to have been described from pre-Silurian formations. Ordovician ostracods which have been assigned to one or other of the kloedenellid genera do not appear on closer inspection to be kloedenellids. The origin of this family is still uncertain. The earliest true kloedenellids, especially species of *Dizygopleura* described from the Silurian sequence in Maryland by ULRICH & BASSLER (1923), show, however, some features in common with zygobolbids. The Zygobolbinae seem to appear somewhat earlier than the Kloedenellidae, at least in Maryland (cf. range chart p. 237). The U-shaped ridge of the zygobolbids resembles the lower half of the letter D.

The straight part of the ridge is L2, whereas the curved part belongs to L3. The same shape is formed by L2 and L3 in *Dizygopleura*. Furthermore S1 is usually longer than S2 both in zygobolbids and *Dizygopleura*, and S3 tends to become closed dorsally (in the zygobolboids this is seen in *Mastigobolbina bifida* ULRICH & BASSLER, 1923). These features are rather unusual but if they denote relationships is still uncertain. The main difference between the Beyrichiidae (including the Zygobolbinae) and Kloedenellidae, is, as stressed by SWARTZ (1936, pp. 556—557), their type of dimorphism. The Kloedenellidae do not develop an antero-ventral pouch or swelling as the Beyrichiidae, but, at least in the early genera, a posterior swelling of the carapace. This does not necessary exclude that the Kloedenellidae have developed from the Beyrichiidae.

Subfamily Kloedenellinae ULRICH & BASSLER, 1908.

Diagnosis: — See p. 264. *Included genera:* — See list p. 270.

Remarks: — The closely related *Kloedenella*, *Dizygopleura*, and *Eukloedenella* are typical members of this subfamily. *Poloniella* agrees so well *Dizygopleura*, even in the hinge structure, that it may be safely included in the Kloedenellinae. VAN VEEN (1921) first pointed out the resemblance between *Poloniella* and *Kloedenella*, and claimed that the latter (in its earlier, broad sense) was a synonym of *Poloniella*. It appears reasonable to regard *Poloniella* as a descendant of *Dizygopleura*, as suggested by WARTHIN (1934, p. 212).

Other Kloedenellinae are *Jonesina*, *Neokloedenella*, and *Lochriella*. *Ellipsella* is very near to *Lochriella* according to COOPER (1946,p. 109). *Lochriella* appears to be intermediate between *Neokloedenella* and *Sansabella* (COOPER, 1941, p. 57). Further Kloedenellinae are *Gillina*, *Kloedenellina*, and *Oliganisus*. *Oliganisus* may be closely related to *Jonesina*. Compare f. inst. *O. geisi* CRONEIS & GUTKE, 1939 (as figured by COOPER, 1941, pl. 12, figs. 2—5) with *Jonesina puncta* MOOREY, 1935 (as figured by COOPER, 1941, pl. 12, figs. 20—21).

Several Kloedenellinae develop a small tubercle or spine near the postero-dorsal angle, at least in some species, as f. inst. *Sansabella*, *Hastifaba*, *Geisina*, *Nuferella*, and *Perprimitia* (the latter being recognized as a kloedenellid by COOPER, 1941, p. 58). These genera appear to be rather closely related. They all have a typical sansabelloid hinge. Their sulcus may be more or less pronounced. Although apparently not developing any tubercle near the postero-dorsal corner, *Kirkbyina* may be near to *Geisina*, and *Knoxina* may be near to *Hastifaba*. *Sargentina*, transferred to the Kloedenellidae by COOPER (1946, p. 117), does not seem to develop any such tubercle but is nevertheless rather closely related to the above-mentioned genera. *Carboprimitia* has hitherto been assigned to the Primitiidae. It differs from this family (also in its old sense) in most features, except in being unisulcate. On the other hand it is very similar to the above-mentioned group in general outline, overlap features, and hingement (channelled between notches), and is here confidently regarded as a kloedenellid. It appears to be rather close to *Hastifaba*.

Microparaparchites and *Paraparchites* have until now been assigned to the Aparchitidae. In the writer's opinion they do not appear to be closely related to the Ordovician type species of *Aparchites*, which has a velate structure not known in *Microparaparchites* and *Paraparchites*. These two genera are most probably related to the contemporaneous *Sansabella* and allied genera, and may be regarded as unisulcate representatives of this group. Both *Microparaparchites* and *Paraparchites* have the characteristic little spine near the postero-dorsal corner often developed in this group. *Proaparchites* has no spine but is probably closely related to these genera. *Pseudoparaparchites*, with a postero-dorsal spine, probably belongs here, too.

Some kloedenellid genera have a more or less well developed ventral lobe; *Perprimitia*, *Chesterella*, *Geffenites*, *Geffenina*, and *Lokius*. *Kirkbyella* appears to be related to these, and is here transferred from the Kirkbyidae to the Kloedenellinae. *Beyrichiella* may be rather close to genera like *Lokius* and *Geffenina*. *Balantoides* may possibly also be related to this group with ventral lobe. *Cornigella* which was removed from the Drepanellidae and included in the Kirkbyidae by SWARTZ (1936, p. 549) may be related to *Balantoides*. *Cornigella tuberculospinosa* (JONES & KIRKBY, 1886), as figured by COOPER (1947, pl. 21, figs. 4—6), agrees rather well with *Balantoides reticulatus* CRONEIS & THURMAN, 1939, as figured by COOPER (1947, pl. 21, figs. 1—3), in general features, except in having more nodes. These extra nodes correspond, however, closely to lobes and ridges in *Balantoides*. *Aechminella*, too, was removed from the Drepanellidae by SWARTZ (1936, p. 549) and placed in the Kirkbyidae. This genus may perhaps also belong rather to the Kloedenellinae, as well as the genus *Beyrichiana*. *Bicornella* resembles such genera as *Kirkbyella* and *Balantoides*. *Boursella* appears to be very close to *Balantoides*.

As discussed by SWARTZ (1933) at least the early genera of the Kloedenellidae show dimorphism. They develop terminal dimorphic swellings, as distinct from the pouches of the Beyrichiidae (SWARTZ, 1936, p. 556).

The hinge of the Kloedenellinae may have an overlap at its anterior end, or a tooth (Dizygopleurid hinge), or there may be a notch at each end of the channelled hinge (Sansabelloid type, cf. COOPER, 1941, p. 55). The hinge may be channelled or nonchannelled, sometimes partly or faintly channelled. The overlap or notches at the ends of the hinge may be more or less well developed, or even missing. Whereas the presence of a Dizygopleurid or Sansabelloid hinge may thus indicate relationships with the kloedenellids, the absence of these types of the hinge does not seem to exclude kloedenellid affinities. The hinge character appears also to vary much within one genus. According to COOPER (1941, p. 57) *Lochriella* may or may not possess the overlap at the anterior end of the hinge. The well developed tooth of *Dizygopleura* appears to be missing in the very closely related genera *Kloedenella* and *Eukloedenella*.

Subfamily Beyrichiopsiinae nov.

Diagnosis: — See p. 264. *Included genera:* — See list p. 269.

Remarks: — Some genera assigned to the Kloedenellidae differ from the other kloedenellid genera in having a conspicuous frill, and usually having transverse ridges and crests. They are here grouped in a new subfamily Beyrichiopsiinae. This subfamily may be allied both to the Kloedenellinae and the Glyptopleurinae. *Glyptopleurina* may develop a frill as the Beyrichiopsiinae. One of the crests in the Beyrichiopsiinae may extend across the sulcus, as is often the case in the Glyptopleurinae and in *Chesterella exuta* CRONEIS & GALE, 1938, as figured by COOPER, 1941, pl. 11, fig. 11. The Beyrichiopsiinae further remind one of *Hastifaba robusta* COOPER (1946), which has a rim and a dorsal crest. *Beyrichiopsis cornuta* JONES & KIRKBY (1886) has a small spine near the postero-dorsal corner. A similar spine or tubercle is common in many genera assigned to the Kloedenellinae.

Subfamily Glyptopleurinae GIRTY, 1910.

Diagnosis: See p. 264. *Included genera:* See list p. 272.

Remarks: — GIRTY (1910) erected a family Glyptopleuridae. Later SWARTZ (1936, p. 557) suggests that the glyptopleurids may be related to the Kloedenellidae. In the writer's opinion this is most probable and the glyptopleurids are here considered as a subfamily of the Kloedenellidae.

The hinge of the Glyptopleurinae agrees very well with that of the Kloedenellinae (cf. f. inst. the hinge of *Glyptopleura circumcostata* COOPER, 1941, p. 40, pl. 7, figs. 1—3). Furthermore the general outline, overlap features, and lobation of the Glyptopleurinae is very similar to the Kloedenellinae. *Mesoglypha* appears to be intermediate between *Sargentina* of the Kloedenellinae and *Glyptopleura.*

Family Kirkbyidae ULRICH & BASSLER, 1923.

Diagnosis: — See p. 264. *Included genera:* — See list p. 272.

Remarks: — The Kirkbyidae are restricted to include only genera with a kirkbyan pit (if a sulcal depression is developed), often a kirkbyan node, and never a ventral lobe. This excludes some genera which have up to the present been included in the Kirkbyidae, such as *Kirkbyella* and *Balantoides*. These have no typical kirkbyan features and do not appear to be allied to any of the typical kirkbyids. They may be allied to such forms as *Chesterella*, and are transferred to the Kloedenellidae.

This leaves in the Kirkbyidae a group of closely related genera. They all have the typical kirkbyan pit, except for *Roundyella*, which only has a muscle scar. As noted by SOHN (1950, p. 35) the overlap and hingement may be reversed, even within one species. The hinge of the Kirkbyidae is very like that of Kloedenellidae. COOPER (1941, p. 47) erected the subfamily Amphissitinae for *Amphissites* and closely related genera. As the family Kirkbyidae has been restricted here, there does not seem to be any longer good enough reasons for retaining a subfamily Amphissitinae and it is considered a synonym of Kirkbyidae.

Strepula has sometimes been included in the Kirkbyidae. The type species of this genus does, however, not show the kirkbyan pit or node, and appears to be closer related to *Steusloffia*. *Strepula* is assigned here to the Bassleratiinae. The Kirkbyidae agree with

Strepula in having transverse crests or ridges, but it should probably still be regarded as an open question whether the Kirkbyidae developed from *Strepula* and allied genera or not.

? Family Youngiellidae KELLETT, 1933.

Diagnosis: — See p. 265. *Included genera:* — See list p. 273.

Remarks: — Since *Youngiella wapanuckensis* HARLTON, 1933 was transferred to *Moorites* by COOPER (1946, p. 123), the type genus of this family includes only one species, *Youngiella rectidorsalis* (JONES & KIRKBY, 1886). Its hinge is peculiar in having a crenulated ridge.

Moorea and *Moorites* have usually been referred to the Youngiellidae. As shown by COOPER (1941), *Moorites* does not have the crenulated hinge of *Youngiella*. Several species, however, agree with *Youngiella* in the general outline, being elongate and having a long, straight hinge.

If *Moorea? cincincta* COOPER, 1941 is a true member of *Moorea*, there can be little doubt that *Moorea* and *Moorites* are closely related. According to COOPER (1941, p. 64) this species has a sansabelloid hinge, which suggests affinities to the Kloedenellidae. Some species of *Moorites* have furthermore a concave ventral margin, as is also known in the Kloedenellidae.

The surface ornamentation of *Moorites* is rather faint, but sometimes peculiarly like that of the later genus *Cytherelloidea* ALEXANDER, 1929. Compare f. inst. *Moorites rhomboidalis* (CRONEIS & BRISTOL, 1939) (as figured by COOPER, 1941, pl. 14, fig. 30) with *Cytherelloidea* sp. SWAIN 1949 (as figured by SEXTON, 1951, pl. 116, fig. 20); and *M. brevis* COOPER (1941, pl. 14, fig. 43) with *C. navesinkensis* JENNINGS, 1936 (as figured by SEXTON, 1951, pl. 116, fig. 8). *Cytherelloidea*, too, tends to develop rather elongate forms, and has sometimes a concave ventral margin. This resemblance between *Morites* and *Cytherelloidea* may be purely accidental. If not, *Moorites* may be related to the Platycopa.

Hardinia was assigned to the Youngiellidae by CORYELL & ROZANSKI (1942). The relationships between *Youngiella* on the one hand and *Moorites*, *Moorea*, and *Hardinia* on the other are uncertain. For the time being the three latter genera may be retained in the Youngiellidae, but only tentatively. The relationships of *Youngiella* (and thus the Youngiellidae) to other families are uncertain. The Youngiellidae are here only tentatively included in the Beyrichiacea.

? Family Miltonellidae SOHN, 1950.

Diagnosis: — See p. 265. *Included genus:* — *Miltonella.*

Remarks: — This family was erected by SOHN (1950) for the one genus *Miltonella.* Its relationships to other families are uncertain, but the family Miltonellidae is here tentatively assigned to the Beyrichiacea because of its straight hinge line, although this alone is no certain criterium for its inclusion in this superfamily.

? Family Alanellidae BOUČEK, 1936.

Diagnosis: — See p. 265. *Included genera:* — See list p. 273.

Remarks: — This family was established by BOUČEK for the one genus *Alanella* from the Ludlow in Bohemia. The valve has a very unusual shape; it is 3 to 4 times as long as high, has a long straight hinge line ending in a spine in each end, and has a well developed frill. Another genus, *Vltavina,* also described from the Bohemian Ludlow by BOUČEK, is, however, very similar to *Alanella* in its general shape; especially one specimen of *Vltavina bohemica* (BOUČEK, 1936, pl. IV, fig. 4). *Vltavina,* too, has the terminal spines. It differs from *Alanella* in not being smooth (it has some horizontal narrow ridges) and in having a sulcus. The sulcus is, however, rather faintly developed in *Vltavina perneri* BOUČEK, 1936, and there is a very faint sulcoid depression in *Alanella bohemica decurtata* BOUČEK, 1936. *Vltavina* does not have a frill. Nevertheless the rather unusual shape of *Alanella* and *Vltavina* and their terminal spines suggest that they are related. *Berounella,* a third genus described in the same paper, appears to be related. It has a frill, and shows a faint tetralobation. *Berounella* agrees with *Alanella* and *Vltavina* in having very long valves with terminal spines. The anterior spine is directed upwards and forwards, not straight forwards as in *Vltavina* and *Alanella.* In this feature *Berounella* is like *Tricornina,* a fourth genus described by BOUČEK from the Ludlow of Bohemia. It appears probable that these four genera are related and may be all included in the Alanellidae. BOUČEK (1936) classed *Tricornina* and *Vltavina* with the Primitiidae, and *Berounella* with the Beyrichiidae; the resemblance to these families is, however, rather superficial.

Agnew (1942) doubts that *Alanella* is an ostracod. If its affinities to *Vltavina* and *Berounella* are accepted, it seems rather probable that *Alanella* is an ostracod, since *Vltavina* and *Berounella* show a faint lobation. It is possible that the Alanellidae are related to the Beyrichiacea, and they are tentatively assigned to this superfamily.

Both *Tricornina* and *Vltavina* were compared with *Acronotella* by Bouček (1936). If *Acronotella* should prove to be related to the Alanellidae, Acronotellidae (Swartz, October 1936) may become a synonym of Alanellidae Bouček (July 1936).

Boučekites and *Přibylites* were compared with *Tricornina* by Přibyl (1951). They differ from the Alanellidae in their general shape, and are only tentatively assigned to this family.

Genera of uncertain family reference.

Beside the many genera tentatively assigned to the different families, there are several others whose taxonomic positions are even more uncertain, often because they are not well enough known. These genera are listed in p. 273. A few remarks are presented below on some of these genera.

Halliella magnapunctata (Kay, 1934) and the type species of *Hallatia*, *H. particylindrica* (Kay, 1934) are no doubt closely related (see figures given by Kay, 1934 and 1940). Kay assumed that *Primitia? sculptilis* Ulrich, 1890 was the type species of *Halliella*. As pointed out by Warthin (1948), the type species is the Devonian *Halliella retifera* Ulrich, 1891. This species is not well known, but it may be rather doubtful if *H. magnapunctata* and *Primitia? sculptilis* are really congeneric with *Halliella retifera*. For this reason it seems better to include *H. magnapunctata* and *P.? sculptilis* in *Hallatia*, which will then also embrace forms with pitted surface. *Hallatia* has a very marked carinal bend, as well as a velate bend. No carinal structure seems to be developed in *Halliella magnapunctata*.

As defined here, *Halliella* and *Hallatia* do not appear to be closely related. *Halliella* may, however, be related to *Punctoprimitia* (cf. f. inst. *P. subaequalis* Swartz & Oriel, 1948) and *Pyxiprimitia*. Kesling (1951, p. 157) has pointed out the close resemblance between *Amphissites lacrimosus* Swartz & Oriel, 1948 and *Halliella retifera* as illustrated by Ulrich (1890, pl. XV, fig. 5). This may suggest that *Halliella* is related to the Kirkbyidae.

Mirochilina, *Novakina*, and *Hippa* are three probably related genera from the Ludlow of Bohemia (cf. Bouček, 1936), whose relationships to other beyrichiaceans are not known.

Neochilina has sometimes been assigned to the Eurychilinidae. Swartz (1936, p. 551) suggests that it should be included in the Hollinidae. It does not, however, show any typical hollinid features, and it appears to be best not to assign it to any of these families at present.

The writer has not seen any material or illustrations of the type species of *Binodella* Bradfield, 1935, *Kirkbyites* Johnson, 1936 (both originally assigned to the Kirkbyidae), and *Golcondella* Croneis & Gale, 1938 (originally assigned to the Drepanellidae) and therefore refrains from commenting their position in the present, revised classification. The same applies to *Kirkbyellina* and *Leioprimitia* (both Kummerow, 1939) and *Cornia*, *Sinusella*, and *Vertexia*, all three erected by Lutkevitch (cf. Agnew, 1944) and *Tribolbina* Latham, 1932.

SUPERFAMILY LEPERDITIACEA BASSLER & KELLET, 1934.

Diagnosis: — See p. 265.

Remarks: — The superfamily Leperditiacea was erected for the two families Leperditiidae Jones, 1856 and Leperditellidae Ulrich & Bassler, 1906. As *Aparchites* was assigned to the latter family, this has lately been referred to as Aparchitidae Jones, 1901. *Aparchites* appears, however, to be a beyrichiacean (cf. p. 231), and the family Aparchitidae is included here in the Beyrichiacea. *Leperditella* may be related to the Leperditiidae, and is tentatively retained in the Leperditiacea, in the family Leperditellidae.

Family Leperditiidae JONES, 1856.

Diagnosis: — See p. 265. *Included genera:* — See list p. 274.

Remarks: — The classification of this family has been discussed by Swartz (1949), who divides it into the two subfamilies Leperditiinae and Isochilininae.

Hessland (1949, p. 148) states that the shell of the Leperditiidae consists of extremely fine prisms, standing perpendicular to the surface, except for a thin layer, and that a prismatic structure is known in *Conchoprimitia* and many other genera. According to

Levinson (1951, p. 554) the Leperditiidae have two shell layers, whereas this has not been recognized in other ostracods. Scott (1951, p. 323) believes that the thin inner layer, and a corresponding thin layer on the outside of the shell may be interpreted as remnants of the inner and outer chitin layer. This would mean that the shell of the Leperditiidae need not be quite different from that of other ostracods.

? Family Leperditellidae ULRICH & BASSLER, 1906.

Diagnosis: — See p. 266. *Included genera:* — See list p. 274.

Remarks: — The position of the Leperditellidae is uncertain. They agree with the Leperditiidae in being rather smooth, and in the general outline; the anterior end being usually the lower, whereas the opposite is usual in the Beyrichiacea. They differ from most Beyrichiacea in having no frill (although the submarginal ridge in the Eridoconchinae may possibly be a velate structure). The Leperditellidae do not show the typical muscle scar or "eye spot" of the Leperditiidae. It is possible that the Leperditellidae are intermediate between the Leperditiidae and Beyrichiacea.

Besides Leperditellinae, two other subfamilies are, tentatively, included in the Leperditellidae, namely Conchoprimitiinae nov. and Eridoconchinae nov.

Subfamily Leperditellinae Ulrich & Bassler, 1906.

Diagnosis: — See p. 266. *Included genus:* — *Leperditella.*

Remarks: — The type species of *Leperditella*, *L. rex* Coryell & Schenk, (1941, new name for *L. inflata* Ulrich, 1892) has been redescribed by Coryell & Schenk (1941). *L. semen*, well figured by Öpik (1937, pl. I, figs. 11—14) appears to be closely related.

? Subfamily Conchoprimitiinae nov.

Pl. 2, fig. 7—9.

Diagnosis: — See p. 266. *Included genera:* — See list p. 275.

Remarks: — This subfamily differs from typical beyrichiaceans in not having any velate or carinal structures. It is as old as (if not older than) any certain beyrichiaceans. It differs from the Leperditiidae in not having any muscle mark of the Leperditiid type, and no "eye tubercle", although the internal mould may show a corresponding node (cf. HESSLAND, 1949, p. 148). The Conchoprimitiinae resemble the Leperditiidae in the general outline (i.a. the anterior half being usually the lower), in attaining a large size (3—4 mm long), in being rather smooth, in the shell structure (cf. HESSLAND, 1949, p. 148), and in having no velate or carinal structures. The Conchoprimitiinae agree rather well with *Leperditella*, but the latter has a more leperditoid outline and is smaller and apparently more thick-shelled. Furthermore the unusual vascular (?) markings of the Conchoprimitiinae (cf. ÖPIK, 1937, p. 10) have not been described in *Leperditella*.

Moult retention in the Conchoprimitiinae.

Conchoprimitia gammae ÖPIK, 1935 as figured by ÖPIK (1935, pl. I, figs. 3a—c) has two concentric grooves, which, as remarked by ÖPIK (1935, p. 4) resemble the growth lines of lammellibranchs and brachiopods. The outer groove is no doubt the boundary between coherent valves of two moult stages (best seen in fig. 3b). This feature is even better demonstrated in a specimen of *Conchoprimites deminuta* figured by ÖPIK (1937, pl. XV, figs. 4—5 (here pl. 2, figs. 8—9). Here an older instar is retained on the right valve (fig. 5), but not on the left (fig. 4). The "primary" and "secondary" shell layers of ÖPIK (1937, p. 12) are thus nothing else than two coherent valves of two moult stages.

Moult retention has been described by LEVINSON (1951) in *Eridoconcha* and *Schmidtella*. The same has been shown by COOPER (1945) to occur in *Ectodemites*.

A faint concentric furrow in some conchoprimitiids may be taken as the impression of the free margin of a coherent moult, which was later shed. This impression was probably made when the new valve was still rather soft, and it is not surprising that this type of groove is rather variable in length and strength. The same feature is described in *Eridoconcha monopleura* by SWAIN & PETERSON (1951, p. 799).

Moult retention, orientation, and ontogeny.

The moult retention is of interest for the orientation, not only of the Conchoprimitiinae, but also of the Beyrichiacea. Even if the

Conchoprimitiinae can be shown to be true members of the Leperditiacea, the median sulcus of *Conchoprimites* may be assumed to be homologous with the median sulcus of the Beyrichiacea. In accordance with the orientation used in this paper, this sulcus is situated slightly in front of the middle.

In specimens with two coherent valves we have two moult stages which we know belong to the same individual (and species). In the holotype of *Conchoprimitia gammae* Öpik (1935, pl. I, figs. 3a—c) (here pl. 2, figs. 6—7) the inner groove (belonging to the attached moult) gives us further the outline of a third, earlier instar. When comparing the outlines of different instars from the same individual, we see that the supposed posterior end grows more than the anterior. This is in agreement with recent ostracods, and indicates that the accepted orientation of the Conchoprimitiinae is correct. As a result of the faster growth of the posterior part, the sulcus in *Conchoprimites* migrates forward during the ontogenetical development. This, too, is in agreement with recent ostracods, where the adductor muscle scar migrates forward (cf. f. inst. Claus, 1868).

The effects of the faster growth of the posterior end on the outline is best seen in the holotype of *Conchoprimitia gammae*. The outline of the smallest instar (indicated by the interior groove) has almost subequal ends, whereas the largest instar is pronounced leperditioid. This agrees well with the growth of *Eoleperditia fabulites*, as described by Scott (1951).

Remarks on the genera: —

Conchoprimitia Öpik, 1935.

Conchoprimitia was split into three genera by Hessland (1949, p. 142); *Conchoprimitia* with two concentric grooves and no sulcus, *Conchoides* with one concentric groove and no sulcus, and *Conchoprimites* with sulcus and with or without concentric grooves.

In the forms described with two grooves, the outer groove is the boundary between coherent valves of two moults. The inner groove is explained as the impression left by an earlier moult, which has later fallen off. One might expect also to find forms with three coherent valves, which would also produce two grooves. Such forms have, however, not been described. The retention of an earlier moult stage is more or less an accidental feature. *Conchoprimitia* (as defined by Hessland) may be regarded as a *Conchoides* with an earlier moult attached, this moult showing the impression of a still earlier valve. *Conchoides* is here considered as a synonym of *Conchoprimitia.*

In forms with one groove, this may be either the boundary between valves of two moult stages, or the impression left by the preceding moult stage. Both types occur.

It may be added that many "*Conchoides*" specimens are practically devoid of any grooves, which means that the preceding moult did not leave any impression on the valve. It appears that some forms assigned to *Conchoides* are even conspecific with species of *Conchoprimitia.* It is f.inst. rather probable that *Conchoprimitia gammae* Öpik, 1935 (type species) is conspecific with the associated *Conchoprimitia* ("*Conchoides*") *glauconitica* Kummerow, 1924. A valve from the type material (illustrated by Öpik, 1935, pl. II, fig. 5) agrees exactly with *C. gammae* with regards to the length-height ratio. "*C. gammae*" may be regarded as specimens of *C. glauconitica* with a coherent instar, the latter showing impression of a still earlier instar.

Isochilina ? erratica is no doubt a *Conchoprimitia* species. Other species are *Leperditia* (*Isochilina?*) *socialis* Brögger, 1882 and *C. broeggeri* Öpik, 1939, as well as nine species assigned to *Conchoides* by Hessland (1949). *Eurychilina? symmetrica* Ulrich, 1894 was transferred to *Conchoprimitia* by Kay (1940, p. 249). This species is, however, not a conchoprimitiid, and its reference to *Conchoprimitia* was doubted already by Hessland (1949, p. 237). It shows a typical velate ridge, and probably belongs to the Eurychilinidae. It appears best to still refer to it as *Eurychilina? symmetrica.* The following species may thus be assigned to *Conchoprimitia:*

Conchoprimitia socialis (Brögger, 1882)
erractica (Krause, 1891)
glauconitica (Kummerow, 1924)
gammae Öpik, 1937 (prob. syn. of *C. glauconitica*)
broeggeri Öpik, 1939
micropunctata (Hessland, 1949)
meganotifera (Hessland, 1949)
rugosa (Hessland, 1949)
ventropunctata (Hessland, 1949)
minuta (Hessland, 1949)
ventroincisurata (Hessland, 1949)

Conchoprimitia dorsodepressula (HESSLAND, 1949)
circumstriata (HESSLAND, 1949)
levis (HESSLAND, 1949)

It is possible that some of these forms may later prove to be synonymous.

Conchoprimites HESSLAND, 1949.

Conchoprimites differs from *Conchoprimitia* in having a median sulcus. *Conchoprimites*, too, shows moult retention. A fine example is seen in *Conchoprimites tolli*. ÖPIK (1937, pl. IX) gives illustrations of three carapaces; in fig. 1 (C. *tolli integra*) the earlier moult has hardly left any impression, in fig. 2 (*C. tolli*) there is a marked groove, and in fig. 3 (*C. tallinnenses*) it is clearly seen that an earlier moult is still attached. These three forms are here considered to be conspecific (refigured here pl. 2, figs. 1—5). It is significant that ÖPIK (1937, p. 11) states that "The inner part of the exterior surface of the valve of *C. tallinnensis* inside the concentric groove corresponds completely to the valve of *C. tolli integra*".

According to ÖPIK (1937, p. 12) *C. deminuta* differs from *C. tallinnensis* (i. e. *C. tolli* with earlier moult attached) in having the sulcus placed more towards the middle of the valve, and having a more elliptical (less leperditioid) carapace. In the holotype of *Conchoprimitia gammae* it is demonstrated that the outline of Conchoprimitiidae may become more leperditioid in later stages (cf. p. 252). In *Conchoprimites* the faster growth of the posterior part results in a more anterior position of the sulcus in later stages (more toward the middle in early stages). If the distance from the sulcus to the posterior border is divided by the distance from the anterior border, this will give a ratio for comparision of the position of the sulcus. The ratio for *C. deminuta* is 1.4. In *C. tallinnensis* the corresponding proportion is 1.5 in the main valve (as measured on fig. 3c pl. IX), but is 1.4 in the attached earlier moult. (The corresponding proportion in the holotype of *C. tolli integra* is 1.5; in *C. tolli* (pl. IX, fig. 2) 1.6). *C. deminuta* corresponds closely with *C. tolli* regarding the height-length ratio.

C ? inusitata may possibly be a still earlier instar, if it is really a conchoprimitiid.

Conchoprimitia leperditioides, *C. hallensis*, and *C. elongata* described by THORSLUND, (1940) should be included in *Conchoprimites*, as pointed out by HESSLAND (1949, p. 236). *C. hallensis* differs from *C. leperditioides* in mainly lacking a concentric groove. As stressed above, such a groove appears to be an accidental feature, and *C. hallensis* is here regarded as a synonym of *C. leperditioides*. *C. elongata* appears to be very closely related to *C. leperditioides*. It differs mainly in being comparatively longer. It is not impossible that this is due to dimorphism, or tectonic influences.

Further species referable to *Conchoprimites* are: *Primitia sulcata* KRAUSE, 1889, *Primitia conchoides* HADDING, 1913, and the type species, *Conchoprimites reticulifera* HESSLAND, 1949.

List of species: —

Conchoprimites sulcata (KRAUSE, 1889)
conchoides (HADDING, 1913)
tolli (BONNEMA, 1909)
tolli integra (ÖPIK, 1937) (syn. of *C. tolli*)
tallinnensis (ÖPIK, 1937) (syn. of *C. tolli*)
deminuta (ÖPIK, 1937) (syn. of *C. tolli*)
leperditioides (THORSLUND, 1949)
hallensis (THORSLUND, 1949) (syn. of *C. leperditioides*)
elongata (THORSLUND, 1949)
reticulifera HESSLAND, 1949

Whereas *Conchoprimitia* and *Conchoides* were assigned to the Aparchitidae, *Conchoprimites* was included in the Primitiidae by HESSLAND (1949). *Conchoprimites* is, however, so close to *Conchoprimitia* that the writer confidently groups them together. The sulcus in *Conchoprimites* may be rather faint sometimes, thus approaching the non-sulcate *Conchoprimitia*.

Ceratocypris POULSEN, 1934 and *Pinnatulites* HESSLAND,1945. These genera were placed in the Aparchitidae together with *Conchoprimitia* and other genera by HESSLAND (1949). They are here tentatively assigned to the Conchoprimitiinae.

?Subfamily Eridoconchinae nov.

Diagnosis: — See p. 266. *Included genera:* — See list p. 275.

Remarks: — The position of this group is uncertain. Its genera have until now been assigned to the Primitiidae, Aparchitidae, and

Leperditellidae. The Eridoconchinae are like the Leperditiidae and Leperditellidae in being lowest in their anterior part. Furthermore the short, slit-like sulcus, tending to bifurcate ventrally reminds one more of the sulcus sometimes present in the Leperditiidae than the typical beyrichiacean sulcus. A somewhat similar sulcus is sometimes developed in the Conchoprimitiinae. The submarginal ridge of *Eridoconcha* resembles that of Bolliinae, but also that of the leperditiid *Saffordellina*. For the time being the Eridoconchinae are tentatively assigned to the Leperditellidae.

Remarks on the genera: — *Cryptophyllus* was split off from the closely related *Eridoconcha* by LEVINSON (1951). According to LEVINSON (1951, pp. 557, 558) *Milleratia* is near to both these genera. KEENAN (1951, p. 565) states that *Milleratia cincinnatiensis* (type species) appears to belong with the genus *Eridoconcha*. *Schmidtella* appears to be near to *Eridoconcha*, as discussed by LEVINSON (1951, p. 558) and KEENAN (1951, pp. 564, 565). The position of *Paraschmidtella* is less certain.

Suborder Podocopa G. O. Sars, 1866.

Many straight-hinged Paleozoic ostracods belong to groups which should be probably included in the suborder Podocopa. Some of these straight-hinged forms appear to be closely related to arcuate-hinged forms.

Family Quasillitidae CORYELL & MALKIN, 1936.

Included genera: — See list p. 275.

Remarks: — Many of the genera included in this family have an ornamental pattern consisting of an anterior curved ridge and two posterior nodes. The pattern resembles the anterior parenthesis sign and a colon, and may be called the *Bufina* pattern, as it is typically developed in *Bufina* (cf. text fig. 12). The pattern may be elaborated or reduced in different ways. As discussed below, it is also found in the Healdiidae.

The family Quasillitidae was established by CORYELL & MALKIN in November 1936 for the genera *Quasillites*, *Janetina*, *Jenningsina*, and *Graphiadactyllis*. In December 1936 KELLETT erected the family Graphiodactyllidae, which is here considered as synonym of Quasillitidae. In 1942 CORRYELL & ROZANSKI added the genus *Paragraphylus*. As shown by SWARTZ & ORIEL (1948, p. 555), *Spinovina* may be a synonym of *Quasillites* and is here included in the family.

The family Ropolonellidae, erected by CORRELL & MALKIN in 1936, appears to be rather close to the Quasillitidae, and it is here proposed to regard the ropolonellids as constituting a subfamily of the Quasillitidae. The above-mentioned genera should then be placed in the subfamily Quasillitinae. It is difficult to separate these subfamilies. The Ropolonellinae have terminal flanges, but this is also true of *Paragraphylus*. *Bufina* was included in the Ropolonellidae by CORYELL & MALKIN (1936). It appears, however, to be closer to *Quasillites* than to *Ropolonellus*, and is transferred to the Quasillitinae. The remaining genera of the Ropolonellinae, namely *Ropolonellus*, *Euglyphella*, *Rudderina*, and *Plagionephrodes* have a rather *Cythereis*-like appearance, whereas the Quasillitinae on the whole resemble more the Healdiidae in general appearance.

Ropolonellus is, apart from its flanges, a smooth ostracod. There can, however, hardly be any doubt that it is closely related to *Euglyphella*. Although somewhat obscured by other ridges, *Euglyphella* has a *Bufina* pattern (see f. inst. *E. sigmoidalis*, *E. compressa*, and *E. jenningsi* as illustrated by CORYELL & MALKIN, 1936, figs. 17, 19, and 20). In *Quasillites* the anterior curved ridge is faintly developed (but clearly discernable, f. inst. in the type species, *Q. obliquus* CORYELL & MALKIN, 1936), and only the lower of the posterior nodes is developed. The same applies to *Spinovina*.

Relationships: — *Ponderodictya* has the *Bufina* pattern and also resembles *Quasillites* and *Bufina* in other features so much that relationships can hardly be denied. As *Ponderodictya* has an arcuate hinge line and is included in the Healdiidae, this means that the Quasillitidae and Healdiidae are rather closely related. Some of the quasillitid genera were earlier included in the Thlipsuridae. *Strepulites* appears to be intermediate between the thlipsurid *Octonaria* and *Euglyphella*. This suggests that the Quasillitidae are related to the Thlipsuridae. As discussed below (p. 261) the Thlipsuridae may be related to the Healdiidae.

KELLETT (1936, p. 774) points out the similarities between *Graphiadactyllis* and post-Paleozoic genera like *Cytheropteron*, and describes furthermore a calcareous inner lamella in *Graphiadactyllis arkansas*. The *Cythereis*-like appearance of the Ropolonellinae, which

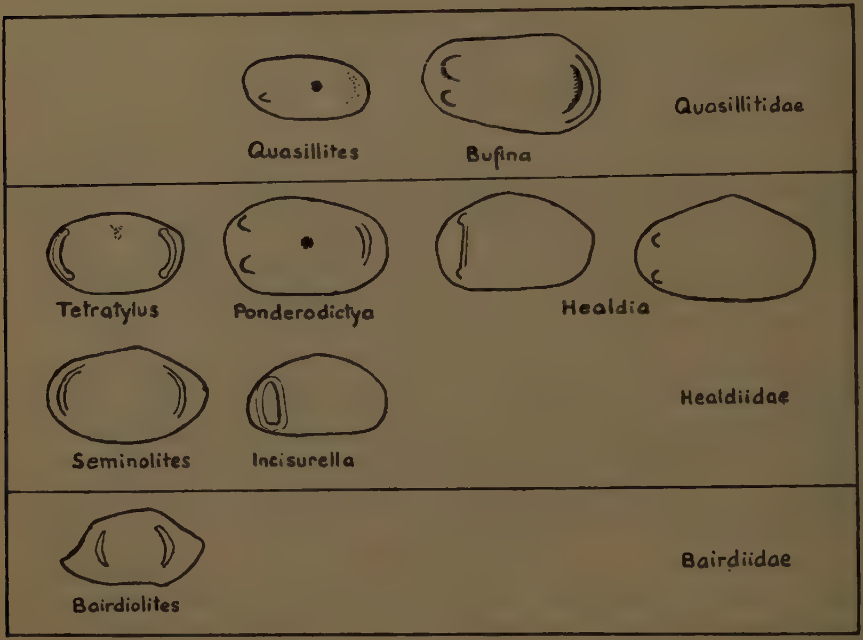


Fig. 12. Structural patterns in Quasillitidae, Healdiidae, and Bairdiidae (*Bufina* pattern and *Seminolites* pattern and varieties of these).

have marginal flanges and a caudal process, is also very suggestive. There seems to be good reasons for including the Quasillitidae in the suborder Podocopa, which is characterized i. a. by the calcareous inner lamella, marginal flanges, and caudal process. As the closely related Healdiidae are included in the suborder Platycopa, this would mean that the Quasillitidae and Healdiidae are near the branching point of these two suborders. (cf. p. 261). The Bairdiidae (arcuate-hinged family of Podocopa) may also develop an ornamental pattern related to the *Bufina* pattern (cf. text fig. 12), as f. inst. *Bairdiolites* which has a *Seminolites* pattern (cf. p. 260). This may indicate relationships between the Bairdiidae and Quasillitidae.

Remarks on *Monoceratina* ROTH, 1928.

Type species is the Pennsylvanian *Monoceratina ventrale* ROTH, 1928 (refigured by SWARTZ, 1936, pl. 83, fig. 3a—b). ALEXANDER (1934) describes some Cretaceous species which he assigns to *Mono-*

ceratina, and maintains that they belong to the Podocopa, i. a. because of their distinct caudal process (ALEXANDER, 1934, p. 58). He further suggests that they are related to *Orthonotacythere*. This relationship now appears to be doubted (cf. SYLVESTER-BRADLEY, 1948, p. 721).

SWARTZ (1936, p. 555) includes *Monoceratina* in the beyrichiacean family Acronotellidae because a caudal process is not developed in the type species. *Monoceratina* is, however, probably not closer related to *Acronotella*.

One may distinguish between species close to *Monoceratina ventrale* and species of the type described by ALEXANDER from the Cretaceous (*M. montuosa* group). *M. bradfieldi*, described by COOPER (1946, p. 39) may be assumed to be closely related to *M. ventrale*, The holotype of *M. bradfieldi* shows no caudal process (COOPER, 1936, pl. 1, figs. 3—6), whereas another specimen shows a small but distinct caudal process (COOPER, 1936, pl. 1, figs. 1—2). Such a caudal process is well developed in a third Pennsylvanian species, *M. macoupeni* SCOTT & BORGER, 1941 (see COOPER, 1946, pl. 1, fig. 13), also belonging to the *M. ventrale* group. Thus the *M. ventrale* group, too, may possibly belong to the Podocopa. Further research may show if the *M. ventrale* and *M. montuosa* group should rather be classed in two genera.

The simple hinge of *Monoceratina* (*montuosa* group); a narrow bar in the left valve, which fits into a shallow groove in the right valve, is similar to the hinge described in the Ropolonellinae by CORYELL & MALKIN (1936, p. 6).

Remarks on the family Healdiidae HARLTON, 1933 (? PLATYCOPA G. O. SARS, 1866).

SCOTT (1944, p. 169) drops this family and includes *Healdia* ROUNDY, 1926 in the Bairdiidae because of a similar muscle scar pattern. TRIEBEL (1950, p. 117), on the other hand, stresses that *Healdia* and *Ogmoconcha* TRIEBEL, 1941 differ from the Bairdiidae in having no true duplicature margin and classes the Healdiidae in the Platycopa, together with the Cytherellidae, which have a similar marginal structure. TRIEBEL (1950, p. 116) further removes *Cavellina* CORYELL, 1928 from the Cytherellidae and includes it in the Healdiidae, because the muscle scar pattern of *Cavellina* agrees with that of *Healdia*, but differs from that of *Cytherella* Jones, 1849. *Ponderodictya* Coryell & Malkin, 1936, originally included in the Cytherellidae, has been shown by Scott (1944) to have a scar of the *Healdia* type and should also be included in the Healdiidae. Quite possibly also a number of other genera (such as *Cribroconcha* Cooper, 1941, *Incisurella* Cooper, 1941, *Paracavellina* Cooper, 1941, *Platychilella* Cooper, 1942, *Seminolites* Coryell, 1928, *Sulcella* Coryell & Sample, 1942, and *Tetratylus* Cooper, 1941) should be included in the Healdiidae. To be sure of this, their muscle scar pattern, hinge, and marginal features should be examined. They agree with *Healdia* in having an ornamental pattern more or less of the *Bufina* type (cf. p. 256). In *Seminolites* and some other genera the pattern consists of an anterior and a posterior curved ridge, together resembling a parenthesis (*Seminolites* pattern). A similar pattern is found in the bairdiid *Bairdiolites* Croneis & Gale, 1938 (cf. text fig. 12).

Remarks on the family Thlipsuridae ULRICH, 1894[1].

This family with arcuate dorsal margin was revised by Swartz, 1932. It is mentioned in this paper because it may be related to the Quasillitidae, especially the Ropolonellinae.

The following genera assigned to the Thlipsuridae by Bassler & Kellett (1934, p. 36) are no longer included in this family: *Phreatura* Jones & Kirkby, 1886 (here included in the Healdiidae), *Poloniella* (which is related to *Kloedenella* as suggested by van Veen, 1921 and Warthin, 1934, p. 212), *Phanassymetria* Roth, 1929 (probably a bairdiid, cf. Morris & Hill, 1952, p. 8, *Ropolonellus* and *Euglyphella* (the two latter were included in the Ropolonellidae by Coryell & Malkin, 1936). The following genera may be retained in the Thlipsuridae: *Craterellina* Ulrich & Bassler, 1913 (synonym of *Thlipsura* by Swartz, 1932), *Eucraterellina* Wilson, 1935, *Eustephanella* Swartz & Swain, 1942 (new name for *Eustephanus* Swartz & Swain, 1941 non Reichenbach), *? Favulella* Swartz & Swain, 1941, *Hyphasmaphora* van Pelt, 1933, *Octonaria* Jones, 1887, *Octonariella* Bassler, 1941, *? Ranapeltis* Bassler, 1941, *Rothella* Wilson, 1935, *? Stibus* Swartz & Swain, 1941, *Strepulites*

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[1] Not Jones, 1887, cf. Coryell & Cuskley, 1934, p. 8.

Coryell & Malkin, 1936, *Thlipsura* Jones & Holl, 1869, *Thlipsurella* Swartz, 1932, *Thlipsurina* Bassler, 1941, and *Thlipsuroides* Morris & Hill, 1952.

Relationships: — The Thlipsuridae may be related to the Ropolonellinae (especially *Euglyphella*) through forms like *Strepulites*. *Favulella*, tentatively assigned to the Thlipsuridae by Swartz & Swain (1941, p. 439), resembles both *Octonaria* and the healdiid *Ponderodictya*. The healdiid *Healdioides* Coryell & Rozanski, 1942 resembles much the thlipsurid genera *Eucraterellina* and *Rothella*. The Thlipsuridae thus appear to be related to the Healdiidae. It is of interest in this connection that Kellett (1935, p. 142) in her discussion of *Healdia* states that there seems to be a weakening of the ornamentation with the passing of time in this genus. This may indicate that the Healdiidae developed from the usually more ornamented Thlipsuridae, a family which seems to appear earlier than the Healdiidae.

The Thlipsuridae do not seem to develop any calcareous inner lamella (although their marginal structure needs closer examination). If the Healdiidae belong to the Platycopa, it is thus possible that the apparently closely related Thlipsuridae should also be placed in this suborder.

Remarks on the relationships of the suborders Podocopa, Platycopa and Paleocopa.

The Quasillitidae, Healdiidae, Thlipsuridae, and possibly also the Bairdiidae appear to be more or less closely related, as discussed above. Both the Quasillitidae and Healdiidae appear later than the Thlipsuridae (cf. range chart p. 276) and may have developed from this family. Unfortunately the marginal structure of the Thlipsuridae is not well known. They seem, however, to lack an inner calcareous lamella and thus agree best with the Platycopa. This would be difficult to explain if the Quasillitidae belong to the Podocopa and the Healdiidae to the Platycopa, as the Bairdiidae (Podocopa) apparently appeared before the Thlipsuridae (cf. range chart, p. 276). It may mean that the earlier forms assigned to the Bairdiidae should not be included in this family (or even suborder), or it may mean that the marginal features are not so useful criteria of affinity. Triebel (1950 p. 116) suggests that the margin of the Platycopa type is primitive, but it is perhaps also possible that the Platycopa type is a reduced Podocopa type. This would seem more probable if the Bairdiidae (Podocopa), really appear earlier than the Platycopa. However, these questions lie beyond the scope of this paper and may probably only be solved when the marginal structures, muscle scar patterns, and hinge structures of the above-mentioned and related families are better known. If the Lower Ordovician species assigned to the Bairdiidae really belong to the Podocopa, this suborder may be at least as old as the Paleocopa, and their branching point be earlier than the known occurrences of ostracods. The relationships of the Paleocopa to other ostracod suborders are thus still uncertain.

Diagnoses of superfamilies, families and subfamilies of Paleocopa.

Superfamily Beyrichiacea: — Straight-hinged ostracods with subequal ends or forward swing. There is a tendency to develop lobes and sulci, carinal, velate, and marginal structures. Smooth forms may resemble smooth forms of other groups; they may differ from the Leperditiacea in the outline, and differ from the Platycopa in apparently not having any inner calcareous lamella. Dimorphism present in many families.

Family Sigmoopsiidae: — Carinal structure well developed. Carinal dimorphism, some individuals having the carinal structure better developed than others. Velate structure may be missing. No dorsal ridge. 1—3 sulci. Median sulcus (S2 usually very long, but may be short. S3 more persistent than S1.

Subfamily Sigmoopsiinae: — As family, but velate structure always present. When the median sulcus is long, it is characteristically sigmoidal.

Subfamily Glossopsiinae: — As family, but velate structure is missing or very faintly developed. Median sulcus alway long, not sigmoidal. The ventral ends of S1 and S2 are their most persistent parts.

Family Tetradellidae: — Velate structure entire or restricted. Velate dimorphism (incurved frill or part of the frill in some individuals) or dimorphic pits between velate and carinal structure, or no dimorphism. Carinal structure may be developed as a ridge (L1 + connecting ridge + L4), or not separated from the extralobal area.

Dorsal ridge may be present. 1—3 long or short sulci. Lateral crests may be present.

Subfamily Tetradellinae: — As family, but velate structure always entire, although a frill may become narrower posteriorly.

Subfamily Piretellinae: — As family, but velate structure restricted (not developed posteriorly). May show dimorphism, some individuals having the frill incurved, sometimes to form a velate pouch (false pouch).

Subfamily Bassleratiinae: — As family, but velate structure always entire. No dimorphism. Always lateral crests or ridges. Only median sulcus well developed. L2 often rather large and node-like.

Family Primitiidae: — Velate structure entire or restricted. Velate dimorphism; some individuals developing a velate pouch (false pouch). One short sulcus. Dorsal ridge may be present, but no lateral ridges or crests. No distinct carinal structure.

Family Eurychilinidae: — Diagnosis depends on whether the Euprimitiinae and Primitiopsiinae are included or not. If they are included, their diagnoses are added to that of the Eurychilininae.

Subfamily Eurychilininae: — Velate structure well developed, entire. Velate dimorphism, some having the frill (or part of it) incurved, not developing, however, a real velate pouch. No or one short sulcus. Dorsal ridge usually not present. No carinal structure.

Subfamily Euprimitiinae: — Velate structure not very conspicuous or missing. Dimorphism in the anterior part of the velate structure, or only some individuals have a velate structure, or dimorphism only as an undefined velate swelling anteriorly in some individuals. One short sulcus, or no well-defined sulcus. Dorsal ridge present or not. No carinal structure.

Subfamily Primitiopsiinae: — Velate structure entire, not very conspicuous. Velate dimorphism, some individuals having a posterior extraneous velate chamber. One pit-like or no sulcus. Dorsal ridge present. No carinal structures.

Family Aparchitidae: — Smooth, nonsulcate, with velate structure. When the velate structure is developed as a frill, it may show dimorphism, some individuals having the frill incurved. No dorsal ridge or carinal structure.

Family Drepanellidae: — Diagnosis depends on whether the subfamilies Bolliinae and Aechmininae are included or not. If they are included, their diagnoses may be added to that of the Drepanellinae.

Subfamily Drepanellinae: — With submarginal ridge, probably a carinal ridge or a fused carinal and velate ridge. No dimorphism observed. No dorsal ridge. 1 sulcus. One or two lobes (L2, L3) may be developed as nodes. The two nodes may be united ventrally to form a U-shaped ridge.

Subfamily Bolliinae: — A submarginal ridge may be present or not, and so may one or two nodes (L2, L3). L2 and L3 may be united ventrally to form a U-shaped ridge. No typical sulcus. No dorsal ridge.

Subfamily Aechmininae: — A submarginal ridge may be present or not. L3(?) usually developed as a spine. A sulcal pit may be present or not. Otherwise no sulci. No dorsal ridge.

Family Acronotellidae: — Diagnosis is not given, as the only certain member, *Acronotella*, is not well enough known. It may be important that the anterior dorsal angle is protruded into a spine.

Family Beyrichiidae: — Velate structure entire. Dimorphism as (carinal?) swellings of the carapace wall, either as a not very well defined swelling, or as a more or less well defined pouch. 1—3 sulci, S1 more persistent than S2. L2 usually node-like.

Subfamily Beyrichiinae: — As family. Sulci short. Often well defined pouch. Velate structure developed as ridge or frill.

Subfamily Zygobolbinae: — As family. L2 and L3, or ridge on top of L3, joined ventrally to form a U-shaped ridge. Velate structure developed as ridge or narrow frill.

Family Hollinidae: — Velate structure well developed, restricted, often with a postero-ventral spine or spur. Different types of velate dimorphism. 1—3 sulci. Median sulcus long or short, in the latter case often widening ventrally. Dorsal part of L3 often bulb-like.

Family Kloedenellidae: — Velate structure present or missing, does not show dimorphism. 0—3 sulci. The early genera, at least, develop posterior dimorphic swelling. Often with conspicuous overlap of valves. Hinge with terminal notches (sansabelloid) or with tooth (dizygopleurid) or without notches or tooth.

Subfamily Kloedenellinae: — As family. Velate structure, when present, not developed as frill.

Subfamily Beyrichiopsiinae: — As family. Velate structure always present, developed as frill. Lateral crests usually present.

Subfamily Glyptopleurinae: — As family, but with ridges (carinae) across the lateral surface.

Family Kirkbyidae: — Velate and other ridges (crests) usually present. When a sulcal depression is developed, this is in the form of a pit (kirkbyan pit). A more or less central, rather large node (kirkbyan node) often present. Surface reticulated. Dimorphism not known.

Family Youngiellidae: — Diagnosis is not given, as the only certain member, *Youngiella*, is not well enough known.

Family Miltonellidae: — Diagnosis, according to SOHN, 1950, p. 37: Straight backed, convex ostracods with a narrow, shallow groove that extends backward from the anterior cardinal angle and curves around and below center of the valve subconcentric with the free margins.

Family Alanellidae: — Typical forms very long, with anterior and caudal spine-like processes. Velate (?) structure present or not, may be developed as frill. 0—3 sulci, but the lobation is faint.

Superfamily Leperditiacea: — Outline leperditioid (backward swing) or with subequal ends. Usually smooth, but may have nodes and a submarginal ridge. Conspicuous dimorphism not observed. A more detailed diagnosis depends on which groups are included in this superfamily beside the Leperditiidae.

Family Leperditiidae: — (Diagnoses mainly after SWARTZ 1949, p. 311). Shells tend to be relatively thick-walled, and are comparatively large, ranging from about 5 to 20 mm in length, or rarely to 30 mm or more. Near the anterior cardinal angle is an inner pit and commonly a corresponding external tubercle, thought to have been the locus of the antero-lateral eye. An adductor scar lies in front of the middle, it is generally well-marked, large, suboval, and consists of numerous, closely spaced though discrete spots; venose lines radiate from the adductor scar. When a short sulcus is developed, it tends to bifurcate ventrally (as in *Isochilina ottawa* JONES, 1858, as illustrated by SWARTZ, 1949, pl. 67, figs. 6 and 9).

Subfamily Leperditiinae: — (Diagnosis after SWARTZ, 1949, p. 311) Inequivalved Leperditiidae, generally with right valve overlapping the left, especially in the ventral region. Flattened borders may be developed terminally, but do not continue along the ventral margin.

Subfamily Isochilininae: — (Diagnosis after SWARTZ, 1949, p. 321). Leperditiidae in which the valves developed flattened borders along the ventral as well as the terminal margins, and in which the closed shell appears essentially equivalved, though one valve may have a marginal flange overlapped by the other.

Family Leperditellidae: — Diagnosis depends on whether the Conchoprimitiinae and Eridoconchinae are included or not. If they are included, their diagnosis may be added to that of the Leperditellinae.

Subfamily Leperditellinae: — Outline leperditioid. Thick-shelled. No lobes or submarginal ridges. The left valve overlaps the right along the free margins. Comparatively small.

Subfamily Conchoprimitiinae: — Outline with subequal ends or slightly leperditioid. Thin-shelled. Left valve overlaps right. A short sulcus, faintly bifurcating ventrally, may be developed. Venose lines may be seen in internal moulds. Length ca. 1—4 mm.

Subfamily Eridoconchinae: — Outline with subequal ends or slightly leperditioid. Thick-shelled. Submarginal ridge may be present, as well as short sulcus, faintly bifurcating ventrally. Comparatively small.

Proposed classification of Paleozoic straight-hinged Ostracods.

Suborder PALEOCOPA nov.
  Superfamily Beyrichiacea ULRICH & BASSLER, 1923
    Family Sigmoopsiidae nov.
      Subfamily Glossopsiinae nov.
        Glossopsis HESSLAND, 1949
        Aulacopsis HESSLAND, 1949
      Subfamily Sigmoopsiinae nov.
        Ogmoopsis HESSLAND, 1949
        Sigmoopsis gen. n.
        Sigmobolbina gen. n.
        Carinobolbina gen. n.
        Bolbina gen. n.
        ?Kiesowia ULRICH & BASSLER, 1908
        ?Ctenobolbina ULRICH, 1890
        ?Winchellatia KAY, 1940
    Family Tetradellidae SWARTZ, 1936
      Subfamily Tetradellinae SWARTZ, 1936 (incl. Dilobellinae KAY, 1940)
        Tetradella ULRICH, 1890
        Dilobella ULRICH, 1894

- Tallinnella ÖPIK, 1937
- Hesslandella gen. n.
- Ceratopsis ULRICH, 1894
- ?Polyceratella ÖPIK, 1937

?Subfamily Piretellinae ÖPIK, 1937

- Piretella ÖPIK, 1937
- Duhmbergia SCHMIDT, 1941 (prob. syn. of Piretella)
- Piretopsis HENNINGSMOEN 1953
- Rakverella ÖPIK, 1937
- Dicranella ULRICH, 1894
- Ctenonotella ÖPIK, 1937
- (Biflabellum ÖPIK, 1935 non DOEDERLEIN)
- Öpikum AGNEW, 1942 (new name for Biflabellum)

Subfamily Bassleratiinae SCHMIDT, 1941 (incl. Ctenentominae SCHMIDT 1941)

- Bassleratia KAY, 1934
- Raymondatia KAY, 1934
- Thomasatia KAY, 1934
- Bellornatia KAY, 1934
- Steusloffia ULRICH & BASSLER, 1908
- Ctenentoma SCHMIDT, 1941 (prob. syn. of Steusloffia)
- Hesperidella ÖPIK, 1937
- Pseudostrepula ÖPIK, 1937
- Rigidella ÖPIK, 1937
- Strepula JONES & HOLL, 1886

Family Primitiidae ULRICH & BASSLER, 1923

- Primitia JONES & HOLL, 1865
- Uhakiella ÖPIK, 1937 (prob. syn. of Primitia)
- Bromidella HARRIS, 1931
- Chilobolbina ULRICH & BASSLER, 1923

Family Eurychilinidae ULRICH & BASSLER, 1923

Subfamily Eurychililininae ULRICH & BASSLER, 1923

- Eurychilina ULRICH, 1889
- Laccochilina HESSLAND, 1949
- Coelochilina ULRICH & BASSLER, 1923
- Apatochilina ULRICH & BASSLER, 1923
- (Platychilina THORSLUND, 1940, non KOKEN)

Platybolbina HENNINGSMOEN, 1953 (new name for Platychilina)
Öpikella THORSLUND, 1940
?Subfamily Euprimitiinae HESSLAND, 1949
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?Euprimites HESSLAND, 1949
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?Neoparchites BOUČEK, 1936
?Punctaparchites KAY, 1934 (syn. of Macronotella by KAY, 1940)
?Macronotella ULRICH, 1894
?Sphenicibysis KESLING 1952
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Drepanella ULRICH, 1890
Scofieldia ULRICH & BASSLER, 1908
?Subfamily Bolliinae BOUČEK, 1936 (incl. Ulrichinae SCHMIDT, 1941)
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Jonesella ULRICH, 1890
?(Placentula JONES & HOLL, 1886
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    - ?(Melanella Wade, 1911)
    - ?Vogdesella Baker, 1924 (new name for Melanella)
    - ?Kinnekullea Henningsmoen, 1948
    - ?Saccelatia Kay, 1940
  - ?Subfamily Aechmininae Bouček, 1936
    - Aechmina Jones & Holl, 1869
    - Paraechmina Ulrich & Bassler, 1923
    - Lindsayella Coryell & Williamson, 1936
    - (Cornulina Coryell & Williamson, 1936 non Conrad)
    - Waldronites Coryell & Williamson, 1942 (new name for Cornulina)
    - Aechminaria Coryell & Williamson, 1936
    - ?Ardmorea Bradfield, 1935
- ?Family Acronotellidae Swartz, 1936
    - Acronotella Ulrich & Bassler, 1923
    - ?Monoceratella Teichert, 1937a
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    - Beyrichia McCoy, 1844
    - Kloedenia Jones & Holl, 1886
    - Welleria Ulrich & Bassler, 1923
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    - Bonnemaia Ulrich & Bassler, 1923

- ?Craspedobolbina Kummerow, 1924

- Family Hollinindae Swartz, 1936
    - Hollina Ulrich & Bassler, 1908
    - Hollinella Coryell, 1928
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    - Hollites Coryell & Sample, 1932 (syn. of Hollinella by Bassler & Kellett, 1934)
    - Falsipolex Kesling & McMillan, 1951
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    - Ctenoloculina Bassler, 1941
    - Tetrasacculus Stewart, 1936
    - Workmanella Croneis & Gale, 1938 (syn. of Tetrasacculus by Cooper, 1941)
    - Pterocodella Croneis & Gale, 1938 (syn. of Tetrasacculus by Cooper, 1941)
    - Bisacculus Stewart & Hendrix, 1945
    - Janischewskya Batalina, 1924
    - ?Sulcicuneus Kesling, 1951
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    - Subfamily Kloedenellinae Ulrich & Bassler, 1908
        - Kloedenella Ulrich & Bassler, 1908
        - Eukoedenella Ulrich & Bassler, 1923
        - Dizygopleura Ulrich & Bassler, 1923
        - Poloniella Gürich, 1896
        - Jonesina Ulrich & Bassler, 1908
        - Nuferella Bradfield, 1935 (syn. of Jonesina by Cooper, 1946
        - Oliganisus Geis, 1932
        - Gillina Coryell & Johnson, 1939
        - Kloedenellina Coryell & Johnson, 1939
        - Neokloedenellina Croneis & Funkhouser, 1938
        - Lochriella Scott, 1942
        - Ellipsella Coryell & Rogatz, 1923
        - Sansabella Roundy, 1926
        - Lamarella Croneis & Funkhouser, 1938 (syn.

- of Sansabella by COOPER, 1941)
- Persansabella CORYELL & SOHN, 1938 (syn. of Sansabella by COOPER, 1941)
- Reversabella CORYELL & JOHNSON, 1939 (syn. of Sansabella by COOPER, 1941)
- Coelonella STEWART, 1936
- Microcoelonella STEWART & SOHN, 1938
- Hastifaba COOPER, 1946
- Geisina JOHNSON, 1936
- Knoxina CORYELL & ROGATZ, 1932
- Sargentina CORYELL & JOHNSON, 1939
- Perprimitia CRONEIS & GALE, 1938
- Lokius CORYELL & JOHNSON, 1939 (syn. of Perprimitia by COOPER, 1941)
- Carboprimitia CRONEIS & FUNKHOUSER, 1938
- Kirkbyina ULRICH & BASSLER, 1908
- Microparaparchites CRONEIS & GALE, 1939
- Paraparchites ULRICH & BASSLER, 1906
- Antiparaparchites CORYELL & ROGATZ, 1932 (syn. of Paraparchites by KELLETT, 1936)
- Proparaparchites COOPER, 1941
- Pseudoparaparchites KELLETT, 1933
- Geffenina CORYELL & SOHN, 1938
- Geffenites CORYELL & SOHN, 1938
- Kellettella DELO, 1930
- Chesterella CRONEIS & GUTKE, 1939
- Beyrichiella JONES & KIRKBY, 1886
- Kirkbyella CORYELL & BOOTH, 1933
- Balantoides MOOREY, 1935
- Verrucosella CRONEIS & GALE, 1938 (syn. of Cornigella by COOPER, 1941)
- Boursella TURNER, 1939
- Cornigella WARTHIN, 1930
- ?Bicornella CORYELL & KUSKLEY, 1934
- ?Beyrichiana KELLETT, 1933
- ?Aechminella HARLTON, 1933
- ?Mammoides BRADFIELD, 1935 (syn. of Aechminella by KELLETT, 1936)

Subfamily Beyrichiopsiinae nov.

Beyrichiopsis Jones & Kirkby, 1886
Deloia Croneis & Thurman, 1938
Leightonella Croneis & Gale, 1938 (syn. of Deloia by Cooper, 1941)
(Denisonia Croneis & Bristol, 1939 non Krefft)
Denisonella Croneis & Bristol, 1942 (new name for Denisonia)

Subfamily Glyptopleurinae Girty, 1910

Glyptopleura Girty, 1910
Ceratopleurina Coryell & Johnson, 1939 (syn. of Glyptopleura by Cooper, 1941)
Glyptopleurites Coryell & Johnson, 1939 (syn. of Glyptopleura by Cooper, 1941)
(Idiomorpha Croneis & Gale, 1939 non Förster)
Idiomorphina Croneis & Gale, 1939 (in Croneis 1939) (new name for Idiomorpha) (syn. of Glyptopleura by Cooper, 1941)
Glyptopleurina Coryell, 1928
Glyptopleuroides Croneis & Gale, 1938
Mesoglypha Cooper, 1941
Venula Cooper, 1941
Svantovites Pokorny, 1950
?Varix Cooper, 1947

Family Kirkbyidae Ulrich & Bassler, 1923 (incl. Amphissitinae Cooper, 1941)

Kirkbya Jones, 1859
Amphissites Girty, 1910
Girtyites Coryell & Booth, 1933 (syn. of Amphissites by Johnson, 1936, and Kellett, 1936)
Kegelites Coryell & Booth, 1933 (syn. of Amphissites by Kellett, 1936)
Albanella Harris & Lalicker, 1932
Aurikirkbya Sohn, 1950
Ectodemites Cooper, 1941
Polytylites Cooper, 1941
Knightina Kellett, 1933
Arcyzona Kesling, 1952

Roundyella Bradfield, 1935
Scaberina Bradfield, 1935 (syn. of Roundyella
by Cooper, 1946)
Kellettina Swartz, 1936
Franklinella Stewart & Hendrix, 1945
Editia Brayer, 1952
Brillius Brayer, 1952
Savagella Geis, 1932

?Family Youngiellidae Kellett, 1933
(Youngia Jones & Kirkby, 1886)
Youngiella Jones & Kirkby, 1895 (new name
?Moorea Jones & Kirkby, 1867 for Youngia)
?Moorites Coryell & Billings, 1932
?Hardinia Coryell & Rozanski, 1942

?Family Miltonellidae Sohn, 1950
Miltonella Sohn, 1950

?Family Alanellidae Bouček, 1936
Alanella Bouček, 1936
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Berounella Bouček, 1936
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?Boučekites Přibyl, 1951
?Přibylites Pokorný, 1950
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Genera of uncertain family reference.
Allostraca Ulrich & Bassler, 1932
Balticella Thorslund, 1940
Bernix Jones, 1884
Budnianella Bouček, 1936
Cyathus Roth & Skinner, 1930
Discoidella Croneis & Gale, 1938
Entoprimitia Kummerow, 1939
Eoconchoecia Moberg, 1895
Hallatia Kay, 1934
Halliella Ulrich, 1891
Hemiaechminoides Morris & Hill, 1952
Hippa Barrande, 1872
Hypotetragona Moorey, 1935a
Karlsteinella Bouček, 1936

- Ladella Spivey, 1939
- Mauryella Ulrich & Bassler, 1923
- Mirochilina Bouček, 1936
- Mooreina Harlton, 1933
- Neochilina Matern, 1929
- Novakina Bouček, 1936
- Öpikatia Kay, 1940
- Polyzygia Gürich, 1896
- Punctoprimitia Stewart & Hendrix, 1945
- Pyxion Thorslund, 1948
- Pyxiprimitia Swartz, 1936
- Tetrasulcata Matern, 1929
- (Ullia Henningsmoen, 1949 non Roewer)
- Ullerella Henningsmoen, 1950 (new name for Ullia)
- Superfamily Leperditicaea Bassler & Kellett, 1934
  - Family Leperditiidae Jones, 1865
    - Subfamily Leperditiinae Jones, 1865
      - Leperditia Rouault, 1851
      - Eoleperditia Swartz, 1949
      - Anisochilina Teichert, 1937
      - Heterochilina Poulsen, 1937
      - Chevroleperditia Swartz, 1949
      - Herrmannina Kegel, 1933
      - Briartina Kegel, 1933
      - Paenaequina Solle, 1935
      - (Holtedahlina Solle, 1935 non Foerste)
      - Holtedahlites Solle, 1936 (new name for Holtedahlina)
    - Subfamily Isochilininae Swartz, 1949
      - Isochilina Jones, 1858
      - Teichochilina Swartz, 1949
      - (Saffordella Ulrich & Bassler, 1923 non Dunbar)
      - Saffordellina Bassler & Kellett, 1934 (new name for Saffordella)
      - Dihogmochilina Teichert, 1937
      - Hogmochilina Solle, 1935
  - ?Family Leperditellidae Ulrich & Bassler, 1906

Subfamily Leperditellinae ULRICH & BASSLER, 1906
    Leperditella ULRICH, 1894
?Subfamily Conchoprimitiinae nov.
    Conchoprimitia ÖPIK, 1937
    Conchoides HESSLAND, 1949 (syn. of Conchprimitia)
    Conchoprimites HESSLAND, 1949
    ?Ceratocypris POULSEN, 1934
    ?Pinnatulites HESSLAND, 1949
?Subfamily Eridoconchinae nov:
    Eridoconcha ULRICH & BASSLER, 1923
    Cryptophyllus LEVINSON, 1951
    Milleratia SWARTZ, 1936
    Schmidtella ULRICH, 1892
    ?Paraschmidtella SWARTZ, 1936
Suborder PODOCOPA G. O. SARS, 1866
Family Quasillitidae CORYELL & MALKIN, 1936 (incl. Graphiodactylidae KELLETT, 1936)
Subfamily Quasillitinae CORYELL & MALKIN, 1936
    Graphiadactyllis ROTH, 1929
    Graphiodactylus ROTH, 1929 (syn. of Graphiadactyllis)
    Paracythere ULRICH & BASSLER, 1932 (syn. of Graphiadactyllis by KELLETT, 1936)
    Bassleria HARLTON, 1929 (syn. of Graphiadactyllis by KELLETT, 1936)
    Quasillites CORYELL & MALKIN, 1936
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    Paragraphylus CORYELL & ROZANSKI, 1942
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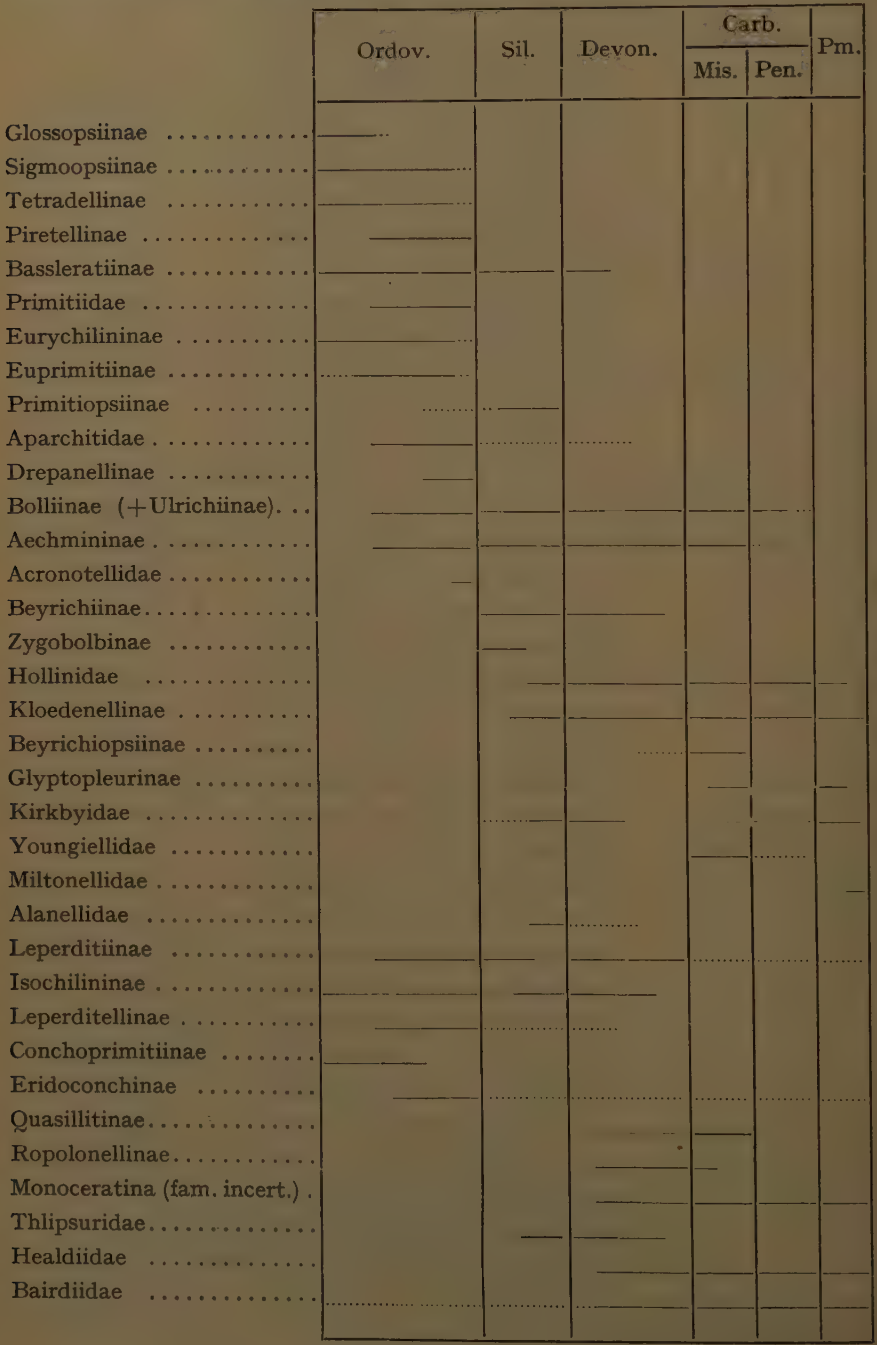
Subfamily Ropolonellinae CORYELL & MALKIN, 1936
    Ropolonellus VAN PELT, 1933
    Euglyphella WARTHIN, 1934
    Rudderina CORYELL & MALKIN, 1936
    Plagionephrodes MOOREY, 1935b

STRATIGRAPHICAL DISTRIBUTION

of the subfamilies and undivided families of straight-hinged Paleozoic ostracods and of the families Thlipsuridae, Healdiidae, and Bairdiidae.



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Manuscript received August 6. 1952.

PLATES 1–2

Plate 1.

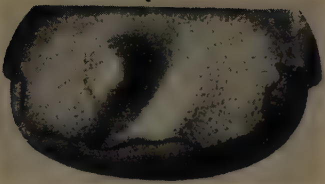
Fig. 1. Hesslandella macroreticulata (HESSLAND, 1949) gen. n. 30 x. (From HESSLAND, 1949, pl. VI, fig. 15).

Fig. 2. Rigidella mitis (ÖPIK, 1935). 20 x. (From ÖPIK, 1935, pl. I, fig. 5).

Figs. 3—4. Rigidella cf. *mitis*. Swedish State Museum of Natural History, Paleozool. Dept., no. Ar. 18690. Collected in drift boulder at Humlenäs, Kristdala in Småland, Sweden by Prof. E. Stensiö. Fig. 3 magnified 37 x. Fig. 4 same specimen in different light, magnified 25 x.

Figs. 5—8. Parabolbina auricularis (JONES, 1887). 30 x. From Mulde, Gotland, Sweden. *Figs. 5—6:* Female type. *Figs. 7—8:* Male type.

PLATE 1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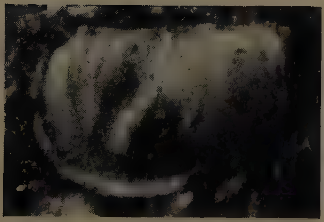
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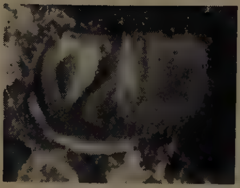
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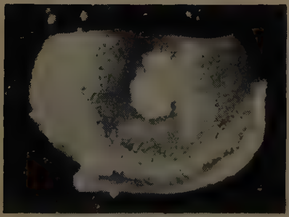
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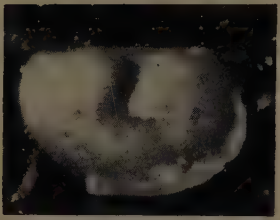
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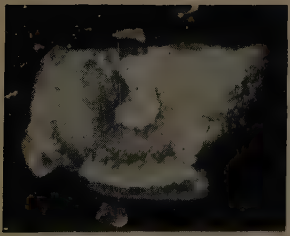
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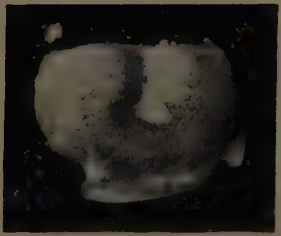
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Plate 2.

(All figures copied from Öpik, 1935 and 1937).

Figs. 1—5. Conchoprimites tolli (Bonnema, 1909). 20 x.

Fig. 1. Figured by Öpik (1937, pl. IX, fig. 1) as *Conchoprimitia tolli integra.*

Fig. 2. Figured by Öpik (1937, pl. IX, fig. 2a) as *C. tolli*. This specimen shows a posterior groove left by the edge of an earlier moult.

Fig. 3. Figured by Öpik (1937, pl. IX, fig. 3a) as *C. tallinnensis.* This specimen has an attached earlier moult, which shows a faint impression posteriorly after a still earlier moult, which was later shed.

Figs. 4—5. Dorsal and ventral view of the same specimen as in fig. 3. The attached moult is clearly distinguished. (Öpik, 1937, pl. IX, figs. 3c and 3b).

Figs. 6—7. Conchoprimitia glauconitica (Kummerow, 1924). 20 x.

Fig. 6. Figured by Öpik (1935, pl. I, fig. 3a) as *C. gammae.* This specimen has an attached moult with a distinct impression left by the ventral edge of a still earlier moult.

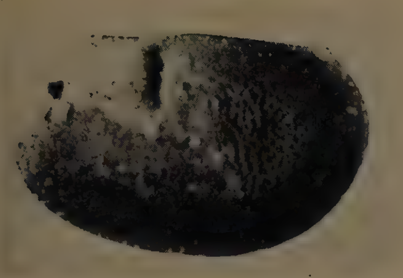
Fig. 7. Same specimen in ventral view. (Öpik, 1935, pl. I, fig. 3b).

Figs. 8—9. Conchoprimites tolli (Bonnema, 1909). 20 x.

Fig. 8. Figured by Öpik (1937, pl. XV, fig. 5) as *Conchoprimitia deminuta.* An earlier moult is attached.

Fig. 9. Left view of the same specimen as in fig. 8. Here the earlier moult has been removed. Figured by Öpik (1937, pl. XV, fig. 4).

PLATE 2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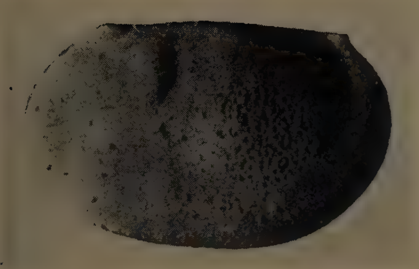
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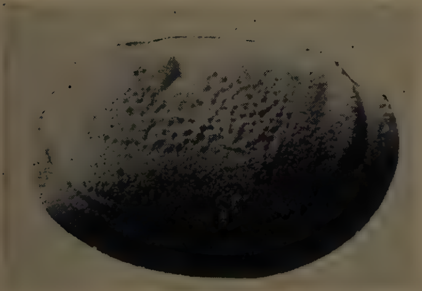
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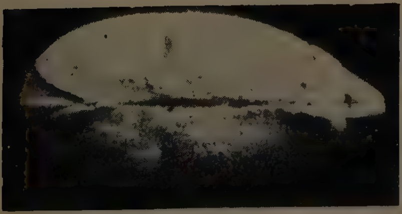
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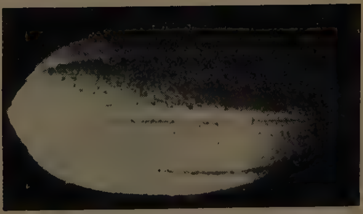
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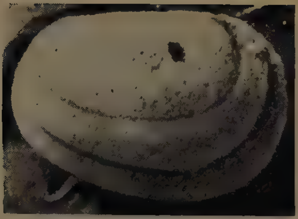
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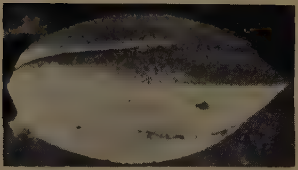
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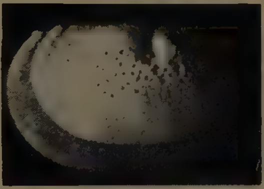
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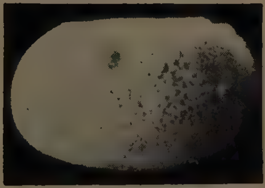
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NOTISER

Errata & Addenda.

G. Henningsmoen: "Remarks on the classification of trilobites" — Norsk geol. tidsskr., *29*, pp. 174—217. Oslo 1951.

p. 184, line 27: read *Xystridura* instead of *Xystridure*
p. 186, line 25, and p. 189, line 27: read *Bergeroniellus* instead of *Bergerionellus*
p. 193, line 13: read Nepeidae instead of Nereidae
p. 203, lines 28—29: read Conocoryphacea instead of Cococoryphacea
p. 204, line 16: read Swinnerton (1915) instead of Walcott (1891)
» line 19: read Olenellidea instead of Olenellidae
» line 20 and line 21: read (Swinnerton, 1915) instead of (Walcott, 1891)
p. 206, line 10: read Westergård, 1946 instead of Westergård, 1936
p. 208, line 13: read Nepeidae instead of Nereidae
p. 209, line 7: read Raphiophoracea instead of Raphiophoridacea
p. 205, line 28: The family name Cephalocoelidae Raymond, 1937 was changed to Catillicephalidae by Raymond, 1938 (Bull. Geol. Soc. Amer., suppl. to vol 48, p. XV), as *Cephalocoelia* was replaced by *Catillicephala*. It may be added here that the family Catillicephalidae, which was not assigned to any superfamily by Henningsmoen (1951, p. 205), has been shown by Shaw (1952, Jour. Paleont., *26*, no. 3, p. 461) to belong to the Zacanthoidacea (=Corynexochida). Shaw (p. 466) has given good reasons for assuming that the cheirurid subfamily Sphaerexochinae has developed from the Catillicephalidae. This means that the superfamily Cheiruracea most probably developed from the Zacanthoidacea, not from the Conocoryphacea as suggested by Henningsmoen (1951, p. 203).
p. 209: add Alsataspidae Turner, 1940 to the list of Raphiophoracean families. As *Alsataspis* is considered a synonym of *Seleneceme* by Whittington (1952, Jour. Paleont., *26*, no. 1, p. 4) the name of the family was changed to Selenecemidae by him.

Paleontological Museum, Oslo.
August 1952.

G. Henningsmoen.

LITTERATUR

TOM F. W. BARTH: *Theoretical Petrology. A text book on the origin and the evolution of rocks.* — John Wiley & Sons, Inc., New York. Chapman & Hall, Limited, London. 387 sider.

Den teoretiske petrografi har hatt mange fremragende forskere i de skandinaviske land. Navn som J. H. L. Vogt, V. M. Goldschmidt, J. J. Sederholm, P. Eskola og mange flere blir stadig sitert i publikasjoner verden over. Når en av de mest kjente nålevende representanter for denne linje, nemlig prof. Barth har funnet tid til å utarbeide en sammenfattende lærebok over dette emne er det med store forventninger man åpner verket.

Boken er inndelt i fire hoveddeler med i alt 58 kapitler. Den første del om jordens fysikk og kjemi avviker ikke særlig fra det man finner i tallrike tilsvarende bøker, men atskillig nyere oppfatninger er kommet med. De senere deler bærer mer preg av forfatterens personlige synspunker. Disse deler gir også uttrykk for oppfatningen man finner hos den skole av nålevende geologer som ofte betegnes som »diffusjonistene«.

Selv om Barth ikke på noen måte nekter for muligheten av at det kan dannes magmatiske dypbergarter, så skinner dog hans tvil på disses eksistens stadig gjennom.

Petrologi er som Barth fremholder et fag som beskjeftiger seg med den uorganiske naturs fysikk og kjemi. Den fysikalske kjemi er utviklet gjennom mer enn et århundrede for en meget stor del av høyt spesialiserte teoretikere i nøye sammenheng med kompliserte laboratorieeksperimenter. Petrologien er ennå i sin spedeste barndom og det er bare meget få av de mange spørsmål som inntil nå er besvart. Ved lesning av Barths bok får man ofte den følelse at vi vet ganske meget og at det som står igjen til de kommende generasjoner er detaljarbeid.

En ikke helt ubetydelig del av boken utgjøres av forholdsvis elementære termodynamiske beregninger som ikke blir benyttet til noe og som på grunn av sin idealiserte karakter, heller ikke kan komme til anvendelse på så kompliserte systemer som de naturlige bergarter. De samme beregninger kan en finne i vanlig fysikalsk-kjemiske lærebøker og i denne bok kan det derfor synes overflødig å ha med så mange termodynamiske likninger.

Atskillige unøyaktigheter i de enkelte beregninger og angivelser skjemmer dessverre boken en del. Den første finnes allerede på side 9. Det er her tale om den varme som produseres av radio-aktive stoffer i jordskorpen. Barth angir her halvveringstiden for K^{40} til 0.55.10^9år. De fleste moderne tabeller angir 1,35—1,42 milliarder år. Denne forskjell er meget viktig. Hadde Barths tall vært riktig ville varmeproduksjonen av K^{40} for tre milliarder år siden vært over 44 ganger så stor som den er i dag, mens den riktige verdi er 4,3—4,7 ganger så stor (Se Harold Urey: The planets, New Haven 1952). Med Barths tall ville det vært åpenbart feilaktig a anvende aktualistiske betraktninger på prekambriske bergarter. Jorden måtte stort sett ha vært flytende under en tynt snerk av en tørrskorpe som stadig ville brytes opp og synke ned. Vann ville bare eksistert i dampform.

På side 17 anføres en likning for den frie energi av en fase som funksjon av denne fases posisjon med et gravitasjonsfelt. Det synes, som om det her er uteglemt tyngdens akselerasjon. Hele den utvikling som kommer i det følgende blir derfor uvanlig, bl. a. blir dimensjonene på uttrykkene forvirrende.

Grunnlaget for avsnittet om de forskjellige grunnstoffers oppholdstid i havet kan synes forholdsvis svakt, i hvert fall for de joner som ikke forekommer i så høye konsentrasjoner at havet kan betraktes som mettet med hensyn til disse joner. Det ville vel for øvrig her vært korrekt med en henvisning til Carstens artikkel i dette tidskrift nr. 28 idet f. eks. tabellen på side 33 åpenbart er hentet fra denne artikkel og bare ubetydelig endret, bl. a. er trykkfeilen rettet.

Under kapitlet om deformasjon i bergarter behandles det meget viktige fenomen, kryping. I dag studeres materialers kryping i en mengde store laboratorier jorden rundt og selv om diffusjonen kan ha betydning i denne forbindelse må man være oppmerksom på at det er dislocation-teorien som er den *alminnelige antatte* i materiallæren. Det virker derfor eiendommelig når dislocationteorien *overhodet* ikke er nevnt i denne bok, men bare den såkalte diffusjonsteori.

Ofte kommer det påstander som synes lite gjennomtenkte, således står det i avsnittet om granulittfacies at granittiske bergarter vil smelte mellom 600°—700° under høyt trykk, derfor kan etter Barths oppfatning granulittfacies ikke svare til høyere temperatur enn ca. 650°. Det er her ikke tatt hensyn til at det kun er under tilstedeværelse av overskudd av vann (ca. 10 % av granittmengden) at man får anatektisk oppsmeltning med så lav temperatur.

Nå er det karakteristisk for granulittene at de er vannfrie, anateksen danner derfor ikke noen grense ved 650°. For den saks skyld kunne øvre temperaturgrense for granulittfacies flyttes atskillige hundre grader.

En hel rekke likninger for mineral-reaksjoner er ufullstendige eller uriktige, idet f. eks. vannstoff inngår på den ene side av en likning, men ikke på den annen. Denne feil er imidlertid ikke konsekvent gjennomført således ikke i likning 1, 4, 5 og 6, men derimot i 8, 9 og 10 i kapitlet om mineralfacies.

Disse kritiske bemerkninger er imidlertid ikke avgjørende og hindrer ikke boken i å ha stor verdi. Hele del 3 om de magmatiske bergarter er meget lærerik, behandlingen av mineralenes fysikalske kjemi er stort sett god. De tallrike eksempler vil gi leseren et godt grunnlag å arbeide videre på. De tallrike litteraturhenvisninger viser at forfatteren har gjennomgått verdenslitteraturen på en grundig måte, selv om en muligens kan synes at utvalget er noe ensartet, idet det først og fremst er de arbeider som faller i tråd med forfatterens syn som er tatt med.

I. Th. Rosenqvist.

JAMES GILLULY, AARON C. WATERS, A. O. WOODFORD: *Principles of Geology.* W. H. Freeman & Co. San Francisco, 1951, 631 s. Kr. 59,90.

Det finnes en lang rekke amerikanske lærebøker i alminnelig geologi. Grunnen til dette er først og fremst at der er et stort marked for slike bøker. Ved de store universiteter kan det være opptil 1000 studenter om året som tar et kursus i ''Physical Geology'', og for hele landet blir tallet ganske betydelig. En bok som slår igjennom kan komme i svære opplag, og det er derfor forholdsvis lett å finne forlegger til en ny bok. (Markedet for lærebøker i petrografi som kunne svare til vårt behov, er derimot langt mindre, og dette er vel hovedårsaken til at det fins så få av det slaget). Blant de mange lærebøker i alminnelig geologi er vel den av Longwell, Knopf og Flint den eneste som har vunnet innpass hos oss ved siden av Ramsay og Holmes. De andre skiller seg ikke vesentlig ut fra den. De samme emner behandles på samme eller lignende måte. Den vekt som er lagt på de forskjellige emner, veksler noe fra bok til bok, ordningen av emnene og utvalget av billedstoff likeså. Men ellers har de meget felles. Hovedvekten er lagt på å meddele kunnskap mer enn å øve studentene opp til selvstendig tenkning. Vi kan stundom synes at bøkene er litt elementære for våre studenter. Det henger sammen med at flertallet av studentene tar alminnelig geologi i sitt første eller annet år på college. De er da 2-3 år yngre enn de fleste av våre geologistudenter, og flertallet av dem har en svakere bakgrunn i realfagene.

Når jeg vil henlede oppmerksomheten på den nye bok av Gilluly, Waters og Woodford, er det fordi den er vesensforskjellig fra de tidligere lærebøker, og fordi jeg tror at den bedre enn disse vil svare til vårt behov. Den legger hovedvekten på å øve opp studentene til selvstendig tenkning. Meddelelsen av kunnskaper er kommet i annen rekke. Fremstillingen gjengir i stor utstrekning den historiske utvikling av vår stilling til problemene. Først presenteres endel grunnleggende fakta. Dernest blir det vist hvordan de ble forklart av de forskere som først, eller på et tidlig stadium, begynte å spekulere på dem. Så antydes i korte glimt utviklingen i vår erkjennelse frem gjennom tiden, og til slutt blir det klarlagt hvor vi står i dag. Dette skjema er fulgt over alt hvor det faller naturlig, og med stort hell. Den historiske fremstilling omfatter bare de springende punkter, og forfatterne har unngått å gjøre den unødig bred.

Eratosthenes beregning av jordens størrelse har fått bedre plass enn vanlig i bøker av denne art, likeså gradmålingen i India som førte til oppdagelsen av isostasien. Den langvarige strid om basaltenes opprinnelse blir ikke bare nevnt som en kuriositet, men forklart ut fra den tids forutsetninger. Det blir vist hvordan en glimrende begavelse som Werner kunne ta fullstendig feil, og hvorledes Desmarest's samvittighetsfulle feltarbeide skaffet de avgjørende beviser mot hans ideer. Forfatternes kommentarer til »basaltstriden« har bud også til våre dagers geologer: " — the failure of Werner's speculations to withstand the test of Desmarest's rigorous field observations showed geologists that the ultimate worth of a theory can only be found in the field. — All these features (bevisene for basaltens eruptive opprinnelse) could have been seen at Stolpen had Werner taken his students there on field trips instead of merely lecturing about the ,,Universal System" and giving them specimens of basalt to study in the laboratory".

Grunnleggelsen av stratigrafien har også fått en bred plass. Adam Smith, Cuvier og Brongniart blir mer enn navn for den som har lest kapitlet om "Geologic Maps, Fossils, Time."

Det er vanskelig å fremheve enkelte kapitler. De kan alle leses med interesse, selv om en mener seg å være forholdsvis fortrolig med stoffet. Et av de beste er ,,Mineral Resources". Her blir i tillegg til det geologiske stoff, de mineralske råstoffenes betydning i verdenshistorien belyst ved en rekke illustrerende eksempler. En opplysning som den at etter 1910 er det blitt utvunnet en større mengde metaller enn i hele menneskehetens historie før 1910, kan gi stoff til atskillig ettertanke. Eller hvà vil det bety for den politiske utvikling i framtiden at verdens største oljereserver ligger i landene rundt den persiske bukt.

Jeg skal ikke ta med flere detaljer, men vil gi boken min beste anbefaling.

De vanlige lærebøker gir i regelen inntrykk av at geologien er en statisk vitenskap, hvor de fleste problemer er klarlagt. Denne bok gir et langt riktigere bilde av fagets stilling: en ung vitenskap som er på stadig marsj framover, med mange uløste problemer og et utall av arbeidsoppgaver. En slik framstilling stiller større krav til studentene. Nettopp derfor burde den passe hos oss.

Anders Kvale.

BRIAN MASON: *Principles of Geochemistry.* Wiley, New York; Chapman & Hall, London, 1952, 276 s., 42 fig., 5 dollars.

Geokjemiens område er blitt avgrenset forskjellig i tidens løp. I vår tid fremhersker den meget omfattende definisjon som selve ordet geokjemi nærmest angir, at geokjemien er læren om de kjemiske elementers forekomst og fordeling i jordkloden, og om hvordan fordelingen er blitt som den er. Observasjonsmaterialet skriver seg fra den tilgjengelige del av jorden; for øvrig bygger man på geofysiske data og på den hypotese at meteorittene gir oss et begrep om forholdene i jordens indre.

Masons bok er ikke stor. Likevel behandler den geokjemien i videste forstand, og det er beundringsverdig i hvilken grad forfatteren har fått med de viktige ting på alle felter, også de nyeste landevinninger. Dessuten er boken meget lettlest, og alle unødvendige spissfindigheter i terminologi og uttrykksmåte er omhyggelig unngått. Den inneholder likevel et stort antall av de vel funderte data. Teorier er fremstilt med sunn kritisk sans. — De forskjellige emner som boken behandler er i korthet følgende. Etter en innledning om geokjemiens historie o. a. følger et kosmokjemisk avsnitt (19 sider), en oversikt over universets, solens, planetenes, meteorittenes sammensetning og opprinnelse. Neste avsnitt behandler jordkloden som helhet (33 sider), teorier om jordens indre, den primære differensiasjon, den pre-geologiske historie, elementenes geokjemiske klassifikasjon. Så kommer et avsnitt som gir de grunnleggende ting fra hjelpevitenskapene termodynamikk og krystallkjemi (23 sider). Det følgende avsnitt om magma og magmabergarter er bokens største (46 sider); det behandler ting som kjemisk og mineralogisk sammensetning, differensiasjon, de viktigste mineraler og deres stabilitetsforhold, eksperimentelle undersøkelser over silikatsmelters krystallisasjon, petrografisk viktige fasediagrammer, reaksjonsprinsippet, »sporelementer« og deres fordeling under krystallisasjonen, pegmatiter, flyktige komponenter, ertsforekomster. Avsnittet om sedimentasjon og sedimentære bergarter (36 sider) behandler bl. a. leirmineralene, og fysisk-kjemiske faktorer som ionepotensialer, pH, oksydasjons-reduksjons-potensialer, kolloidale prosesser; anrikning av sporelementer; beregninger over totale sedimentmengder. De 3 følgende avsnitt handler om hydrosfæren (15 sider), atmosfæren (14 sider) og biosfæren (20 sider). Her får vi bl. a. betraktninger over forandringer i havets og luftens sammensetning gjennom tidene, og en omtale av kull og petroleum. Under metamorfose og metamorfe bergarter (34 sider) omtales bl. a. metamorfosen som geokjemisk prosess, de metamorfe bergarters kjemiske og mineralogiske sammensetning, mineralenes stabilitet, metamorfosens termodynamikk og kinetikk, faseregelen og mineralfasiesprinsippet, subsolidus-likevekter, metasomatose, »fronter«, anatexe. Det siste avsnitt (6 sider) inneholder betraktninger over den geokjemiske syklus for jordskorpen.

Boken er en fornøyelse for alle som er interessert i geokjemiens vidstrakte felt, og for geologistuderende tror jeg den må være særlig velkommen. Den er også fremgått av forelesninger beregnet først og fremst på geologistuderende.

Ivar Oftedal.

NORSK GEOLOGISK FORENING

Lov for Norsk Geologisk Forening, se bind 28, p. 263.
Medlemsliste for Norsk Geologisk Forening, se bind 30.

Møte 338. Torsdag 27. mars 1952.

Tilstede: 23 medlemmer og 3 gjester.

Innvalg av et nytt medlem ble godkjent:

356. *Lauritz Bjerrum,* sivilingeniør, Geoteknisk Institutt, Blindern, Oslo.

Foreslått av P. Holmsen og G. Holmsen.

Foreningen bifalt styrets anmodning til A. Granlie om å fortsette som foreningens regnskapsfører.

Formannen meddelte at G. Henningsmoen var utpekt til å være N. G. F.'s representant ved Geologkongressen i Algier 1952.

Chr.Oftedahl holdt kveldens foredrag: »*Lavaene i Oslofeltet*«.

I ordskiftet etter foredraget deltok T. Barth, L. Størmer og foredragsholderen.

Møte 339. Tirsdag 29. april 1952.

Tilstede: 21 medlemmer og 4 gjester.

Innvalg av et nytt medlem ble godkjent:

357. *G. K. Rutherford* M. Sc. p. t. Vollebekk.

Foreslått av J. Låg og T. Strand.

Dr. *R. C. Moore* (University of Kansas) holdt foredrag om *"The Geological Features of Japan"* og *"The Pleistocene of the Great Plains of North America."*

I ordskiftet etter foredragene deltok O. Holtedahl, L. Størmer, H. Major, H. Rosendahl og foredragsholderen.

Møte 340. Torsdag 15. mai 1952.

Til stede: 20 medlemmer og 8 gjester. Geoteknisk forenings medlemmer var innbudt til møtet.

Innvalg: Som nytt medlem ble godkjent:

358. *Arne Hofseth,* ing. Løkken verk. Foreslått av E. Kiil og N. Spjeldnæs.

Geolog *E. L. Mertz* (København) holdt foredrag om: «*Geologiske Probleme i skandinavisk Geoteknik*».

I ordskiftet etter foredraget deltok: H. Rosendahl, G. Holmsen, N. Spjeldnes, A. L. Rosenlund, H. Sørensen, L. Bjerrum, J. Låg, A. Løddestøl, R. C. Vold og foredragsholderen.

Møte 341. Torsdag 6. november 1952.

Til stede: 32 medlemmer og 17 gjester.

Innvalg: Som nye medlemmer ble godkjent:

359. *K. S. Heier*, stud. real., Geologisk Museum, Oslo 45. Foreslått av T. F. W. Barth og H. Neumann.

360. *Gunnar Gillberg*, Fil. lic., Stockholm Högskola, Stockholm. Foreslått av J. A. W. Bugge og A. Grønlie.

Styret fremla et forslag fra I. Rosenqvist, T. Barth, I. Oftedal og Chr. Oftedahl om en metamorfosekongress i Norge 1954. I diskusjonen om dette forslaget deltok: I. Oftedal, O. Holtedahl, S. Føyn, Chr. Oftedahl, B. Dietrichson og T. Gjelsvik.

Foredrag av cand. real. *Just Gjessing: «Isskuringsanalyser i indre Oslofjord«.*

I ordskiftet etter foredraget deltok: K. Strøm, F. Isachsen, W. Werenskiold, S. Føyn og H. Rosendahl.

Foredrag av *O. Holtedahl: «Studier over Norges overflateformer»*.

I ordskiftet etter foredraget deltok: F. Isachsen, K. Strøm, W. Werenskiold, T. Gjelsvik, H. Rosendahl, E. Dahl, R. Feyling-Hanssen og foredragsholderen.

Møte 342. Mandag 17. november 1952.

Til stede: 26 medlemmer og 8 gjester.

Foredrag av professor *L. R. Wager* (Oxford): *«Layered intrusions»*. Etter foredraget hadde T. Barth et lengere innlegg med lysbilder om tilsvarende norske forhold. Dessuten deltok B. Dietrichson, T. Vogt og foredragsholderen i ordskiftet.

Møte. 343 (julemøte). Tirsdag 9. desember 1952.

Til stede: 34 medlemmer og 26 gjester.

Innvalg: Som nytt medlem ble godkjent:

361. *Erling Johansen*, stipendiat, Kråkerøy pr. Fredrikstad. Foreslått av O. Holtedahl og H. Rosendahl.

Kåseri av *N.-H. Kolderup: «Norsk geologi på Tredveårskrigens tid»*.

I ordskiftet etter kåseriet deltok O. Holtedahl og foredragsholderen.

Årsberetning for Bergens Geologiske Klubb 1952.

Bergens Geologiske Klubb har i 1952 hatt 8 foredragsmøter med et gjennomsnittlig deltakerantall på 13 medlemmer.

Følgende foredrag har vært holdt:

26/2 —52. *I. Th. Rosenqvist:* Noen feltspatundersøkelser ved Geologisk institutt.
26/3 —52. *I. Undås:* Om isfri områder langs Norges kyst under siste istid.
26/5 —52. *A. M. Rosenqvist:* Et syntetisk mineral i markasittgruppen.
15/10—52. *N.-H. Kolderup:* Om gabbroen i Hyllestad og Fjaler.
6/11—52. *I. Hernes:* Om bergartene på Moldehalvøya.
19/11—52. *A. Samuelsen:* Litt om breavsmeltningen mellom Østerdalen og Gudbrandsdalen.
4/12—52: *A. Kvale:* Strukturproblemer i de norske og skotske kaledonider.
17/12—52: Julemøte. Stud. real. *I. Bryhni:* Fra en tur til Spitsbergen sommeren 1952.

Styret i 1953 blir som i 1952, med professor *Niels-Henr. Kolderup* som formann og konservator *Hans Holtedahl* som sekretær.

GEOLOGNYTT

Norges Geologiske Undersøkelse

Statsgeolog I, dr. philos. *Arne Bugge* tok avskjed med alderspensjon fra 25. april 1952.

Statsgeolog I, dr. philos. *Harald Bjørlykke* sluttet 1. juli 1952 for å overta en geologstilling i Norsk Bergverk A/S.

Statsgeolog II *Arthur O. Poulsen* ble beskikket som statsgeolog I fra 1. mars 1952.

Statsgeolog II *Per Holmsen* ble beskikket som statsgeolog I fra 1. juli 1952.

Cand. real. *Tore Gjelsvik* ble beskikket som statsgeolog I fra 1. juli 1952.

Cand. real. *Rolf Selmer-Olsen* ble ansatt som statsgeolog II fra 1. juli 1952.

Cand. real. *Johannes Færden* ble ansatt som statsgeolog II fra 1. juli 1952.

Dr. philos. *Christoffer Oftedahl* ble ansatt som statsgeolog II fra 1. juli 1952.

Cand. real. *Steinar Skjeseth* ble ansatt som statsgeolog II fra 1. juli 1952.

Bergingeniør *Brynjulf Dietrichson* vikarierer midlertidig som vitenskapelig assistent fra 1. mars 1952.

Engelsk statsborger, geolog *Peter Padget,* M.Sc., er midlertidig ansatt i statsgeolog II-stilling fra 1. juli 1952.

Sivilingeniør *Brynjolf Bruun* er beskikket som laboratorieingeniør I ved Norges Geologiske Undersøkelses kjemiske laboratorium fra 1. juli 1952.

Statsgeolog I *Olaf Anton Broch* er meddelt 1 års permisjon fra 1. mars 1952 for å overta en midlertidig stilling som professor i mineralogi ved Universitetet i Punjab, Pakistan.

Universitetet i Oslo.

Dr. techn. *K. Kristoffersen* har fratrådt sin stilling som konservator ved Mineralogisk-Geologisk Museum for å tiltre stillingen som laboratoriesjef i A/S Norsk Jernverk fra 1. juli 1952.

Cand. real. *J. A. Dons* er ansatt som konservator ved Mineralogisk-Geologisk Museum fra 1. juli 1952.

Mag. scient. *H. Sørensen* er ansatt som vitenskapelig assistent ved Mineralogisk-Geologisk Museum fra 1. februar 1952 og fratrer stillingen ved årets utgang.

Stud. real.. *K. Heier* er ansatt som vitenskapelig assistent ved Mineralogisk-Geologisk Museum fra 1. januar 1952.

Stud. real. *Fredrik Hagemann* er ansatt som vitenskapelig assistent ved Paleontologisk Institutt fra 1. september 1952.

Cand. real. *Harald Carstens* sluttet som vitenskapelig assistent ved Mineralogisk institutt 15. april 1952 for å overta en stilling ved Fosdalens Bergverks-Aktieselskab.

Som ny vitenskapelig assistent ved Mineralogisk institutt er fra samme dag ansatt cand. mag. *Thor Siggerud.*

Stud. real. *Natascha Heintz* er ansatt som museumsstipendiat i geologi, med plikt til å arbeide vinteren 1952—53 ved Paleontologisk Museum.

Professor dr. *Anatol Heintz* er i 1950 valgt til Foreign Member of the Geological Society of London.

Professor dr. *Leif Størmer* er i 1950 valgt til Foreign Member of the Geological Society of London.

Professor dr. *Leif Størmer* har fått tjenestefri i 4 måneder for å delta i den 19. internasjonale geologkongress i Alger, og for å foreta studiereiser til Marokko, Italia, Frankrike og Belgia. Han er oppnevnt som representant for Universitetet i Oslo ved kongressen.

Konservator *Gunnar Henningsmoen* reiste til den 19. internasjonale geolog kongress i Alger som representant for Norsk Geologisk Forening.

Professor *A. F. Frederickson,* Washington University, St. Louis, Missouri, har vært gjesteprofessor med Fulbright-stipendium ved Mineralogisk-Geologisk Museum 1951/52. Han har studert metasomatose i bergarter ved Kragerø.

Professor *K. B. Krauskopf,* Stanford University, California, kom høsten 1952 som gjesteprofessor med Fulbright-stipendium til Mineralogisk-Geologisk Museum for å drive geokjemiske studier.

Matematisk-naturvitenskapelig embetseksamen med mineralogi-petrografi som hovedfag er fullført i vårsemestret 1952 av *Fredrik Christian Abel Huseby.* Avhandling: »De kvartære avsetninger syd for Storsjøen i Rendalen«.

Matematisk-naturvitenskapelig embetseksamen med historisk geologi og paleontologi som hovedfag er i årene 1949/52 fullført av følgende:

1. *Nils Spjeldnæs.* Avhandling: »Studies on the Lowest Silurian Rocks North of Oslo.« (1949).
2. *Steinar Skjeseth.* Avhandling: »Geologisk kartlegging av Neshalvøya (ved Mjøsa).« (1950).
3. *Thore Winsnes.* Avhandling: »Trekk av indre Isfjords geologi«. (1951).
4. *Knut Aarhus.* Avhandling: »Skjellbanker i indre Østfold.« (1952).

Universitetet i Bergen.

Cand. real. *Ivar Hernes* er ansatt som vikar i et år fra 1. juli 1952 for førsteamanuensis dr. philos. *Ivan Th. Rosenqvist.*

Norges Geotekniske Institutt.

Dr. philos. *Ivan Th. Rosenqvist* er ansatt som leder for forskningsområdet fysikk-kjemi-mineralogi fra 1. august 1952.

Cand. mag. *Finn Jørstad* er ansatt som skredforsker fra 1. januar 1953.

Til forfattere av artikler som ønskes opptatt i tidsskriftet.

Maskinskrevet manuskript adresseres til redaksjonen, Geologisk institutt, Universitetet i Bergen — ikke til noen personlig.

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Unødig ordrik fremstilling bør unngås.

Hvert vitenskapelig arbeid som trykkes i tidsskriftet skal innledes med et »Abstract« på få linjer. For avhandlinger på skandinaviske sprog bør det dessuten leveres et kort resymé på engelsk, fransk eller tysk.

Til overskrifter bruker tidsskriftet følgende typer:

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I manuskriptet bør forfatterne merke av med blyant eller blekk hvilke typer de mener bør brukes i de forskjellige overskrifter. Sørg for å få likeverdige overskrifter med samme typer.

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eller skrives med kapiteler.

Bergen, februar 1953.

NORSK GEOLOGISK TIDSSKRIFT

Institutions and persons interested in securing *back volumes* are informed that Vol. 3, Vol. 4 and Vol. 5 are out of print.